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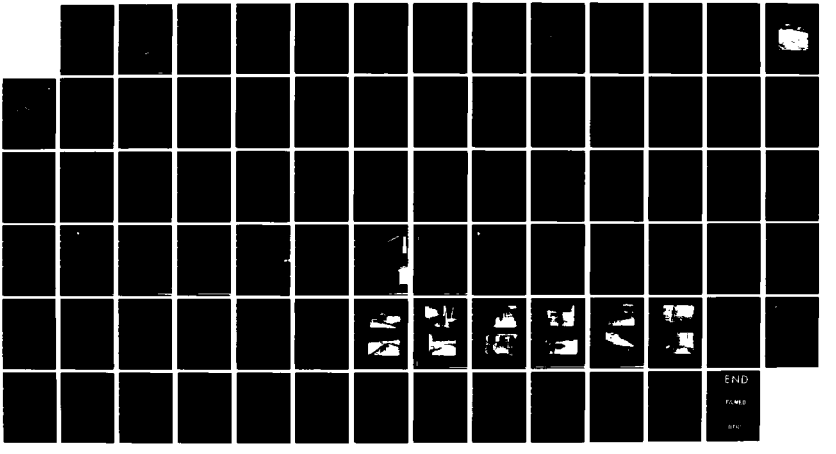

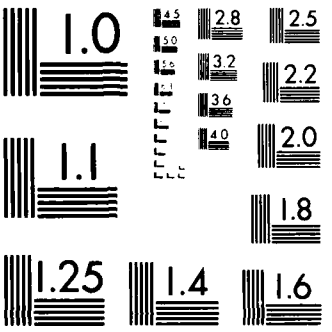

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AD-A154 643

MERRIMACK RIVER BASIN
FRAMINGHAM, MASSACHUSETTS

FOSS RESERVOIR DAM
MA00339

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

APRIL 1981

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MA 00339	2. GOVT ACCESSION NO. A134 643 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Foss Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS	5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254	12. REPORT DATE April 1981 13. NUMBER OF PAGES 54
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Merrimack River Basin
Framingham, Massachusetts
Stony Brook, tributary of the Sudbury River, Merrimack River Basin Date of Inspection: December 5, 1980

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Foss Reservoir Dam is a 1640 foot earthfill dam with a maximum height of 29 feet. Although the dam is in good condition, the spillway will not pass the peak test flood oitflow without overtopping the dam. The dam has been classified inthe intermediate size and high hazard categories. It is recommended that the Owner employ a registered professional engineer to conduct a more detailed hydraulic and hydrological study.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

JUL 07 1931

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Foss Reservoir Dam (MA-00339) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Foss Reservoir Dam would likely be exceeded by floods greater than 35 percent of the Probable Maximum Flood (PMF). Our screening criteria specifies that a dam classified as high hazard with a spillway capacity insufficient to discharge fifty percent of the PMF be judged as having a seriously inadequate spillway. As a result this dam is assessed as unsafe, non-emergency until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as it would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

We recommend that within twelve months from the date of this report the owner of the dam engage the services of a qualified registered engineer to determine further the potential of overtopping the dam and the need for and the means to increase project discharge capacity. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed and round-the-clock surveillance should be provided during periods of heavy precipitation or high project discharge.

NEDED

JUL 07 1981

Honorable Edward J. King

I approve the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the program.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering and to the owner, State of Massachusetts, Metropolitan District Commission, Boston, Mass. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

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FOSS RESERVOIR DAM

MA 00339

MERRIMACK RIVER BASIN
FRAMINGHAM, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00339

Name of Dam: Foss Reservoir

Town: Framingham

County and State: Middlesex County, Massachusetts

Stream: Stony Brook, tributary of the Sudbury River, Merrimack River Basin Date of Inspection: December 5, 1980

Foss Reservoir Dam is a 1,640-foot long earthfill dam built in 1878. The reservoir is presently used as an emergency water supply for the Metropolitan Boston area. The maximum storage capacity is 4,350 acre-feet. The dam has a maximum height of 29 feet, and the top varies from Elevation (El) 185.4 to 186.0 National Geodetic Vertical Datum (NGVD). A spillway and gatehouse are located near the south abutment of the dam. The spillway is a narrow crested, stone masonry weir, 100 feet long, with the crest at El 179.6. The gatehouse contains two outlets, 4 feet wide by 5 feet high and two water supply pipes 4 feet in diameter. The inverts of the outlets and pipes are at El 156.75. Flow into the outlets is controlled by sluice gates located in the gatehouse. An earthfill dike 250 feet long and 4 feet high also impounds the reservoir and is located about 1,000 feet north of the main dam. The top of the dike is at El 185.8.

There are minor deficiencies which must be corrected to assure the continued performance of this dam. This conclusion is based on the visual inspection of the site and a review of the available data. Although the dam is in good condition, the spillway will not pass the peak test flood outflow without overtopping the dam. Therefore, the project is in fair overall condition.

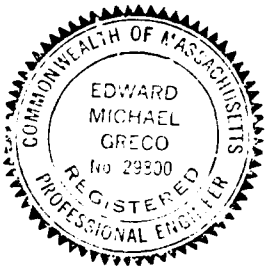
The following minor deficiencies were observed at the site: localized erosion on the top of the dam; localized growth of brush and trees on the dam; animal burrows on the downstream slope of the dam; and a dense growth of brush and trees on the dike.

Based on Corps of Engineers' guidelines, the dam has been classified in the intermediate size and high hazard categories. A test flood equal to the full probable maximum flood (PMF) was used

to evaluate the capacity of the spillway. The peak test flood inflow is estimated to be 13,100 cubic feet per second (cfs). There is no adjustment for surcharge storage due to the delayed arrival of the peak inflow. The peak test flood outflow is 13,100 cfs, resulting in a pond level at El 187.1. The test flood would overtop the dam by 1.7 feet. Hydraulic analyses indicate that the spillway can discharge 4,650 cfs, or 35 percent of the test flood outflow before the dam is overtopped.

It is recommended that the Owner employ a qualified registered professional engineer to conduct a more detailed hydraulic and hydrologic study to further assess the need for and means to increase the project discharge capacity and the ability to withstand overtopping. In addition, the Owner should repair the deficiencies listed above, as described in Section 7.3. The Owner should also implement a program of biennial technical inspections, a plan for surveillance of the dam during and after periods of heavy rainfall, and a plan for notifying downstream residents in the event of an emergency at the dam.

The measures outlined above and in Section 7 should be implemented by the Owner within a period of 1 year after receipt of this Phase I Inspection Report.



Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 29800

Approved by:

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703

This Phase I Inspection Report on Foss Reservoir Dam (MA-00339) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, MEMBER
Geotechmical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general conditions and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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OVERVIEW
FOSS RESERVOIR DAM
FRAMINGHAM, MASSACHUSETTS

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General. Foss Reservoir Dam has a drainage area of 27.6 square miles of which 22.3 square miles drains into Sudbury Reservoir (see Figure D-1, Drainage Area Map). Hydraulic analyses conducted for Sudbury Reservoir Dam are given in a Phase I Inspection Report dated 1978. The additional drainage area downstream of Sudbury Reservoir is gently rolling and moderately developed. About 3.8 percent of this area is ponds and swamps. Ground elevations in the watershed range from 180 to 550.

Foss Reservoir has a surface area of approximately 232 acres, and a maximum storage capacity of 4,650 acre-feet at El 185.4.

The two low level outlets can discharge a combined flow of 2,700 cfs when the reservoir is at El 179.59 which is the crest of the spillway. With the reservoir at this elevation and with no additional inflow, the outlets can lower the reservoir by 1 foot in about 1 hour. The two water supply lines could also discharge approximately 300 cfs with the reservoir at El 179.59.

5.2 Design Data. There are no hydraulic or hydrologic computations available for the design of the spillway at Foss Reservoir Dam. However, the drawings show a design surcharge of El 181.35.

5.3 Experience Data. There is no record of overtopping of the present dam, which was constructed in 1878. The MDC records indicate the following reservoir levels occurred during periods of high runoff:

Reservoir Elevation	Storm
182.80	August 1955
181.67	March 1938
181.57	September 1938
180.82	January 1979

5.4 Test Flood Analysis. Foss Reservoir Dam has been classified in the "intermediate" size and "high" hazard categories. According to the Corps of Engineers guidelines, a test flood equal to the full PMF (Probable Maximum Flood) should be used to evaluate the capacity of the spillway.

SECTION 4

OPERATING AND MAINTENANCE PROCEDURES

4.1 Operating Procedures

a. General. According to MDC personnel the standard operating procedure is to visit the dam daily, read the reservoir level, and, if necessary, adjust the gate settings to release water downstream. The MDC is required to discharge 1.5 mgd into the Sudbury River downstream of Stearns Reservoir.

b. Warning System. There is no warning system in effect at this dam.

4.2 Maintenance Procedures

a. General. The dam is generally well maintained, however, the dike is not maintained. The MDC is responsible for maintenance of the facility. Typical maintenance procedures have included clearing brush and mowing grass on the dam. One inspection report by the Massachusetts Department of Public Works has been obtained and is included in Appendix B.

b. Operating Facilities. Routine maintenance of the operating facilities consists of periodic cleaning of screens in the gatehouse. In 1956, a portion of the stone masonry spillway was replaced, the rest of the masonry was repointed, and miscellaneous repairs were made to the gatehouse. The sluice gates on the outlets are reportedly operable. Water was last released into the water supply pipes in April 1980.

4.3 Evaluation. There is a program for maintaining the embankment and appurtenant structures in good operating condition, however, the dike has not been maintained. In addition, there is no program of regular technical inspections, no plan for surveillance of the embankment during and after periods of heavy rainfall, and no emergency warning system in effect. This is extremely undesirable, considering that the dam is in the high hazard category. These programs should be implemented, as recommended in Section 7.3.

gatehouse is in good condition. The outlets are submerged and were not visible during the inspection. The sluice gates on the outlets are reportedly in operating condition. Mechanisms to operate the sluice gates are located on the main floor of the gatehouse (see Photo No. 6). Openings covered with gratings are located in the floor of the gatehouse. These openings provide access to the sluice gates. Screens are located on the upstream side of the wet well to collect debris. At the time of inspection, water was discharging from the outlet next to the spillway.

Two cast-iron water supply are located in the gatehouse. The pipes are submerged and were not visible from the floor of the gatehouse. The pipes discharge 0.9 mile downstream into the Sudbury Aqueduct.

An earthfill dike is located about 1,000 feet north of the main dam. The upstream and downstream slopes are overgrown with brush and trees (see Photos 11 and 12). Riprap has been placed on the upstream slope. The top of the dike is relatively clear of vegetation, however, erosion has occurred due to tire ruts which exposed tree roots embedded in the embankment. There was no seepage observed at the downstream toe, but the dike was not impounding any water at the time of inspection.

d. Reservoir Area. Moderately developed sections of the City of Framingham are located around the reservoir. Residential development is located on the north and east sides of the reservoir, high rise apartment buildings are to the south, and commercial development occurs along the west side. Most of the land is cleared with 5 to 10 percent slopes. There is a high potential for future development to occur in the reservoir area.

e. Downstream Channel. The spillway and low-level outlets discharge into a downstream pond (Stearns Reservoir). The earth slopes around the sides of the pond are covered with grass and there are no overhanging trees (see Photograph No. 7).

About 400 feet downstream of the dam, an embankment and bridge for Route 9 crosses the pond. Water flows under the bridge through a 35-foot long, 13-foot high opening which will restrict the flow from the test flood.

3.2 Evaluation. The visual inspection indicates that the dam is in good condition, however, the dike is in need of maintenance. The stated deficiencies which must be corrected to assure the continued performance of this dam and measures to improve these conditions are outlined in Section 7.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The Phase I Inspection of the dam at Foss Reservoir was performed on December 5, 1980. A copy of the inspection checklist is included in Appendix A. A previous inspection was conducted by the Massachusetts Department of Public Works in 1973. A copy of that report is given in Appendix B. Selected photographs taken during our Visual Inspection are included in Appendix C.

b. Dam. The dam is an earthfill structure with a spillway and gatehouse. There is no evidence of seepage or settlement of the dam.

An area of localized erosion caused by trespassing and surface runoff was noted at the top of the dam, adjacent to the gatehouse (see Photo NO. 10). Tire ruts also exist on the top of the dam, and a rut was observed across the top of the dam at the bend near the north abutment. The riprap on the upstream face of the embankment is intact, although there is no chinking between the blocks.

About 10 large trees from 2 to 3 feet in diameter are growing on the top and slopes of the dam near the north abutment (see Photo No. 3). One small tree is growing at the downstream toe near the south abutment, and some brush is growing in the riprap on the upstream face.

Five animal burrows about 1 inch in diameter were also observed on the downstream slope of the dam south of the spillway. The burrows are scattered at various locations on the slope.

c. Appurtenant Structures. The spillway is a narrow-crested, stone masonry weir without flashboards. The stone masonry was in good condition. Slight efflorescence and minor openings in the joints were visible on the downstream face of the weir (see Photo No. 9). However, no areas of leakage through the masonry were observed.

Two low-level outlets are located in the gatehouse at the north end of the spillway. As shown in Photo 1, the

valid. One of the three outlet openings shown on the original drawings has since been changed to a 48-inch cast-iron pipe that discharges into the Sudbury Aqueduct instead of into the downstream channel.

The datum for the elevations shown on the original drawings is unknown. The MDC currently uses 185.24 Boston City Base datum for the crest of the spillway. This elevation is equal to 179.59 NGVD, as compared to 175.24 given in the original design data (page B-12). Therefore, 4.35 feet should be added to the elevations on the original drawings in order to convert to NGVD.

SECTION 2

ENGINEERING DATA

2.1 General. The engineering data available for this Phase I inspection includes a description and drawings of the project published in 1882 by the Boston Water Works (see Figures B-3 through B-6 and pages B-9 through B-12). There is also a drawing showing repairs to the spillway prepared by the Metropolitan District Commission (MDC) and dated 1956. The data were obtained from the MDC office in Framingham, Massachusetts. There are no specifications or computations available from the Owner, State, or County agencies. The only previous inspection report is dated 1973 and was prepared by the Massachusetts Department of Public Works. A copy of that report is also given in Appendix B.

We acknowledge the assistance and cooperation of personnel from the Massachusetts Department of Environmental Quality Engineering, Division of Waterways; the Massachusetts Department of Public Works; and the MDC-Water Division. In addition, we acknowledge the assistance of Mr. Edward Ginsburg, Superintendent of The MDC, who provided information on the history and operation of the dam.

2.2 Construction Records. The only construction records available for the dam are a written description and drawings given in a report entitled "Additional Supply From Sudbury River" by the Boston Water Works, dated 1882. The drawings are not labelled "as-built".

2.3 Operating Records. Operating records are available. Daily records are kept of the elevation of the pool and the amount of rainfall at the dam.

2.4 Evaluation

a. Availability. Some engineering data is available for this dam.

b. Adequacy. The lack of detailed hydraulic, structural and construction data did not allow for a definitive review. Therefore, the evaluation of the adequacy of this dam is based on the visual inspection, past performance history, and engineering judgment.

c. Validity. Comparison of the available drawings with the field survey conducted during the Phase I inspection indicates that the available information is generally

(9) Grout curtain: none

(10) Other: earthfill dike located 1,000 feet north of main dam: 250 feet long, 4 feet high with top at El 185.8.

h. Diversion and Regulating Tunnel: N/A

i. Spillway

(1) Type: narrow-crested

(2) Length of weir: 100 feet

(3) Crest elevation: 179.59

(4) Gates: none

(5) Upstream channel: earthfill bottom slopes at 3:1

(6) Downstream channel: stone-paved bottom extends 60 feet downstream

j. Regulating Outlets

(1) Invert El: 156.75

(2) Size: 5 feet by 4 feet

(3) Description: two rectangular openings

(4) Control mechanism: sluice gates

(5) Other: two 48-inch cast-iron pipes extend from the gatehouse 0.9 mile downstream and discharge into the Sudbury Aqueduct.

(5) Test flood pool: 10,400

e. Storage (acre-feet)

(1) Normal Pool: 3,300

(2) Flood control pool: N/A

(3) Spillway crest pool: 3,300

(4) Top of dam: 4,650

(5) Test flood pool: 5,050

f. Reservoir surface (acres)

(1) Normal pool: 232

(2) Flood-control pool: N/A

(3) Spillway crest: 232

*(4) Test flood pool: 232

*(5) Top of dam: 232

g. Dam

(1) Type: earthfill

(2) Length: 1,640 feet

(3) Height: 29 feet (maximum)

(4) Top width: 20 feet

(5) Side slopes: 2:1 upstream and downstream

(6) Zoning: none

(7) Impervious core: stone masonry wall for a length of 1,140 feet

(8) Cutoff: timber sheet piling for a length of 384 feet

*Based on the assumption that the surface area will not significantly incrase with changes in pool elevation from 179.59 to 187.1.

(4) Ungated spillway capacity at test flood elevation: 6,850 cfs at El 187.1.

(5) Gated spillway capacity at normal pool elevation: Not applicable (N/A).

(6) Gated spillway capacity at test flood elevation: N/A

(7) Total spillway capacity at test flood elevation: 6,850 cfs at El 187.1.

(8) Total project discharge at top of dam: 4,650 cfs at El 185.4.

(9) Total project discharge at test flood elevation: 13,100 cfs at El 187.1.

c. Elevation (feet above National Geodetic Vertical Datum of 1929 (NGVD)). A benchmark was established at El 179.59 at the crest of the spillway. This elevation was obtained from the MDC records.

(1) Streambed at toe of dam: 156

(2) Bottom of cutoff: 130

(3) Maximum tailwater: 162.2 (water surface downstream at time of inspection)

(4) Normal pool: 179.6

(5) Full flood control pool: N/A

(6) Spillway crest: 179.6

(7) Design surcharge (Original design): 181.35

(8) Top of dam: 185.4 to 186.0

(9) Test flood surcharge: 187.1

d. Reservoir (Length in feet)

(1) Normal pool: 10,400

(2) Flood control pool: N/A

(3) Spillway crest pool: 10,400

(4) Top of dam: 10,400

of the three original outlets now contains a pipeline that extends downstream and discharges into the Sudbury aqueduct.

A previous inspection report indicates that in 1972 the dam was in good condition. Repairs were made in 1956 to the stone masonry on the spillway, which had been damaged during the 1955 hurricane.

i. Normal Operating Procedures. Personnel from the MDC reportedly visit the dam once a day. At that time, they record the elevation of the reservoir and adjust the gate settings as necessary to release water downstream. The MDC is required to discharge a minimum of 1.5 million gallons per day (mgd) into the Sudbury River downstream of Stearns Reservoir. In order to do this, water is released from the upstream reservoirs, including Foss Reservoir.

1.3 Pertinent Data

a. Drainage Area. The drainage area which is approximately 17,670 acres (27.6 square miles) extends into the towns of Southborough, Westborough, Northborough and Marlborough (see Figure D-1 in Appendix). About 80 percent of the watershed (22.3 square miles) drains into the Sudbury Reservoir located 2.3 miles upstream of Foss Reservoir. The topography is generally gently rolling. About 4 percent of the drainage area is ponds and swamps. Undeveloped portions of the drainage area consist of 50 percent woodland, and 50 percent open fields. Dense residential and commercial development occurs in the vicinity of the Massachusetts Turnpike, Route 9, and in the City of Marlborough at the northern end of the watershed.

b. Discharge. Discharge from Foss Reservoir is over the spillway and/or through openings in the gatehouse. The discharge flows into Stearns Reservoir which is impounded by a dam 0.9 miles downstream. Water can also be drawn out of Foss Reservoir through two 48-inch diameter water supply lines that discharge into the Sudbury Aqueduct.

(1) Outlets (two): Size - 4 ft. x 5 ft. Invert El. - 156.75.
Combined Discharge Capacity - 2,760 at El 179.59

(2) Maximum known reservoir elevation:
182.8 (August 1955)

(3) Ungated spillway capacity at top of dam 4,650 cfs at El 185.4

A 250-foot long, 4-foot high earthfill dike is located about 1,000 feet north of the main dam. The top of the dike is 8 feet wide and varies from El 185.8 to 186.0. The upstream face is a 2:1 slope covered with riprap. The downstream face is a 2.25:1 slope covered with brush and trees. There are no discharge facilities at the dike.

c. Size Classification. Foss Reservoir Dam has been classified as "intermediate" on the basis of its maximum storage capacity of 4,650 acre-feet. A dam classified as intermediate must have a height between 40 feet and 100 feet or a maximum storage capacity between 1,000 acre-feet and 50,000 acre-feet.

d. Hazard Classification. There are 10 homes located between 500 and 1,000 feet downstream of the dam (see Flood Impact Area shown on the Location Map). The foundations of these structures are approximately 9.5 feet above the pond downstream of the dam. An assumed failure of the dam would result in a flood wave 14 feet high in the pond downstream of the dam as compared to a flood height of 6 feet prior to failure. The pond would overflow its channel and flood the area around the houses. It is possible that more than a few lives could be lost and an excessive amount of property damage could occur. Accordingly, the dam has been placed in the "high" hazard category.

e. Ownership. The dam is owned by the State of Massachusetts, Metropolitan District Commission (MDC), 20 Somerset Street, Boston, Massachusetts 02114. Mr. Francis Faucher, Acting Director, Water Division (telephone 617-727-5274) granted permission to enter the property and inspect the dam.

f. Operator. The dam is operated by personnel from the MDC Water Division in Framingham, Massachusetts.

g. Purpose of the Dam. The water in Foss Reservoir is currently used as an emergency water supply by the MDC which provides water for Boston and 33 surrounding communities.

h. Design and Construction. Foss Reservoir Dam, originally named Reservoir Dam No. 3, was completed in 1878 as part of a series of three water supply reservoirs on the Sudbury River. Drawings and a description of the project are given in a report dated 1882 prepared by the Boston Water Works. The drawings show that the dam was constructed essentially as it appears today, except that one

b. Description of Dam and Appurtenances

Foss Reservoir Dam is a 1,640-foot long, earthfill dam with a maximum height of 29 feet at the spillway (see Plan of Dam and Sections in Appendix B and photographs in Appendix C). The top of the dam is 20 feet wide and varies from El 185.4 to 186.0. The upstream face is a 2:1 (horizontal:vertical) slope. The upstream slope from the south abutment to about 400 feet north of the gatehouse is covered with riprap between El 170 and El 183. North of that area, the upstream slope is covered with grass. The downstream face is a 2:1 slope covered with grass. Available drawings indicate that the dam is an unzoned embankment with a central core wall made of stone masonry (see Figure B-4). The core wall extends from the south abutment to about 750 feet north of the gatehouse. The drawings also show that a timber sheet piling cutoff extends into a sand foundation up to 13 feet below the base of the dam (see Figure B-3).

The spillway, located near the south abutment of the dam, is 100 feet long and has a narrow-crested stone masonry weir. The floor of the approach channel slopes at 3:1. The sidewalls of the spillway are vertical, stone masonry walls 6 to 28 feet high (see Section CD on Figure B-4). There are no stoplogs or flashboards on the crest of the spillway which is at El 179.6. The channel below the spillway is a 200-foot wide pond which is part of Stearns Reservoir (Reservoir No. 1). The sides of the channel are 10 to 15-foot high earth slopes and the floor is paved with stone for a distance of 60 feet downstream. Water from the pond passes under the Route 9 highway through a 35 foot by 13 foot culvert and joins the main body of Stearns Reservoir.

A gatehouse at the north abutment of the spillway contains two low-level outlets and two water supply pipelines. The two low-level outlets are 4-foot wide by 5-foot high openings, located on the downstream face of the gatehouse. The water supply lines are 48-inch diameter cast-iron pipes. The inverts of the outlets and water supply pipes are at El 156.75. Flow through the outlets and water supply pipes is controlled by upper and lower level sluice gates in the wet well of the gatehouse. The outlets discharge into the pond below the spillway. The two water supply pipes extend from the gatehouse to the Sudbury Aqueduct. The aqueduct begins at Stearns Reservoir Dam and extends to Chestnut Hill Reservoir in Brookline.

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

FOSS RESERVOIR DAM

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-80-C-0054, dated April 18, 1980, has been assigned by the Corps of Engineers for this work.

b. Purpose

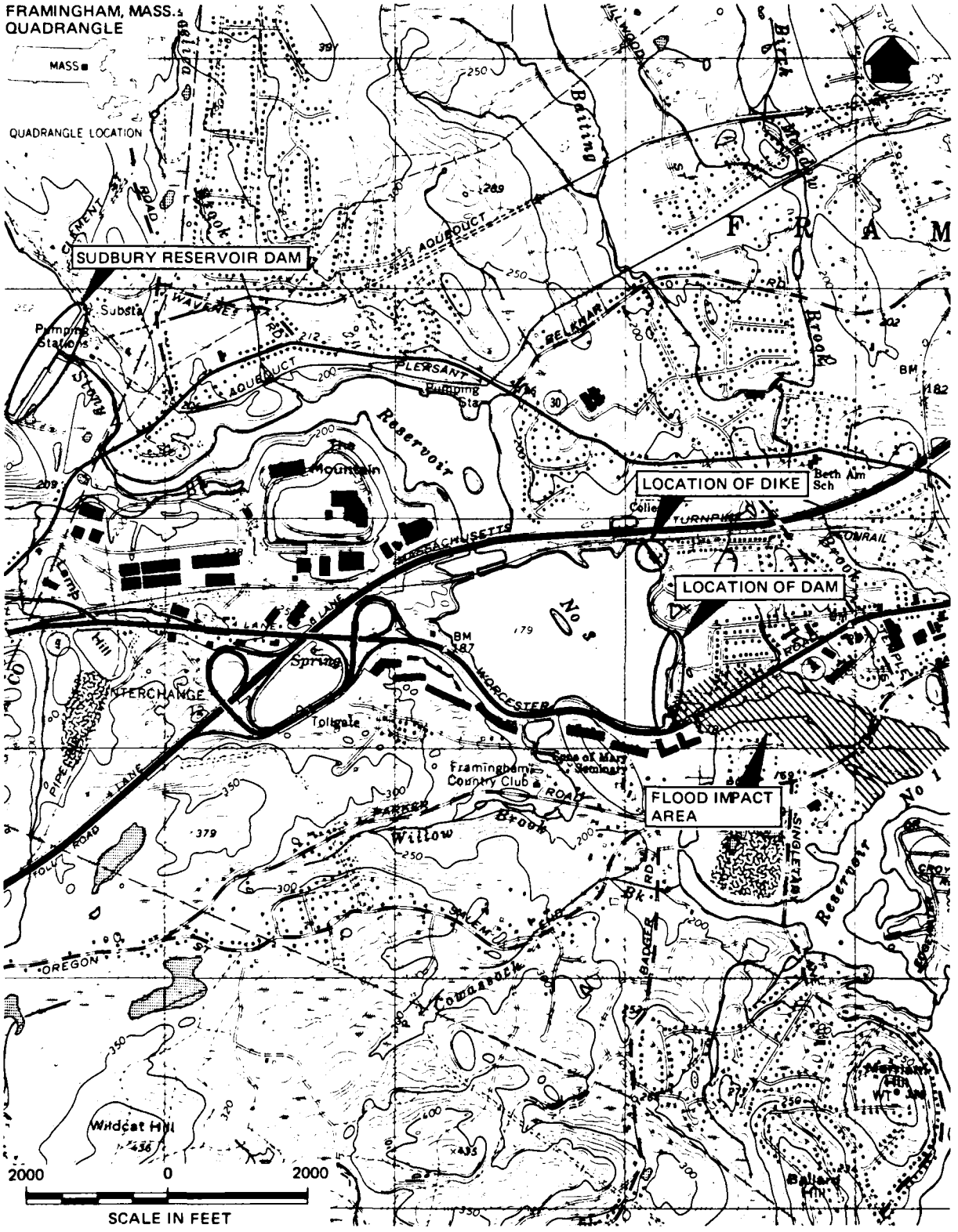
(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to quickly initiate effective dam safety programs for non-Federal dams.

(3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. The dam is located on Stony Brook about 0.8 miles upstream of the confluence with the Sudbury River, in the Merrimack River Basin. The dam is in the Town of Framingham, Middlesex County, Massachusetts (see Location Map). The coordinates of this location are Latitude 42 deg. 17.7 min. north and Longitude 71 deg. 27.6 min. west.



LOCATION MAP - FOSS RESERVOIR DAM

The test flood inflow for Foss Reservoir consists of the full PMF runoff from the drainage area below Sudbury Reservoir plus the full PMF outflow from Sudbury Reservoir Dam.

The PMF rate for the drainage area downstream of Sudbury Reservoir watershed was calculated to be 1,300 cfs per square mile. This calculation is based on the average slope of 1.7 percent in the drainage area, the pond-plus-swamp area to drainage area ratio of 3.8 percent, the U.S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Flow Rates (dated December 1977). For this analysis, the peak flow rate was determined to be between the guide curves for flat and coastal and for rolling topography.

Applying the full PMF rate to the 5.3 square mile drainage area below Sudbury Reservoir results in a peak inflow of 6,890 cfs. However, a larger peak inflow of 11,100 cfs from Sudbury Reservoir occurs about 4 hours later. At that time, the inflow from the drainage area downstream is 2,000 cfs. This results in a maximum test flood inflow of 13,100 cfs for Foss Reservoir Dam. No adjustment for surcharge storage is made because the reservoir would already be full from earlier runoff. Therefore, the peak test flood outflow is 13,100 cfs and would result in a pool at El 187.1.

Hydraulic analyses indicate that the spillway can discharge 4,650 cfs or 35 percent of the test flood outflow with the pond at El 185.4, which is the low point on the top of the dam.

Hydraulic analyses indicate that the 1/2 PMF would result in the reservoir at El 186.1. The spillway can discharge 71 percent of the 1/2 PMF outflow before the dam is overtopped.

During the test flood, the low point on the dam would be overtopped by 1.7 feet. About 6,850 cfs would discharge over the spillway, and about 6,250 cfs would discharge over the dam. Where critical flow occurs over the dam, the water would be 1.0 foot deep at a velocity of 5.7 feet per second (fps).

5.5 Dam Failure Analysis. Although a failure could occur at any point along the dam, for the purposes of this report, the failure is assumed to occur north of the spillway where the dam is directly upstream of a housing development. The peak discharge rate due to failure of the dam was calculated to be 26,600 cfs with the reservoir at El 185.4. This calculation is based on a maximum head of 17.4 feet and an assumed 180-foot wide breach occurring in the embankment. Failure of the dam would produce a flood wave about 14 feet high in the downstream pond as compared to a flood height of 6 feet prior to failure.

There are 10 houses located between 500 and 1,000 feet downstream of the dam and close to the north side of the pond. The foundations of these structures are approximately 9.5 feet above the normal level of the pond. Due to the wide valley downstream of the dam, some attenuation of the flood flow is expected. The assumed failure of the dam could result in a flood wave that would rise 5 feet above the ground surrounding these houses. It is possible that this flooding could cause the loss of more than a few lives and an excessive amount of property damage. Accordingly, the dam has been placed in the "high" hazard category.

SECTION 6

STRUCTURAL STABILITY

6.1 Visual Observations. The evaluation of the structural stability of Foss Reservoir Dam is based on a review of previous inspection reports, a review of available drawings and the visual inspection conducted on December 5, 1980.

As discussed in Section 3, Visual Inspection, the dam is in good condition. No seepage or settlement was observed along the embankment. Areas of erosion and some growth of trees were observed on the top and slopes of the dam. A few small animal burrows are located on the downstream slope south of the spillway. Also, the dike is heavily overgown with brush and trees.

6.2 Design and Construction Data. Construction of Foss Reservoir Dam was completed in 1878. Computations for design of the dam, spillway and outlets are not available.

Drawings from a report dated 1882 prepared by the Boston Water Works show the construction of the dam (see Figures B-3 through B-6). It is not known if these are "as-built" drawings. The drawings show that the dam is an unzoned earthfill embankment founded on sand. An impervious core wall made of stone masonry is located in the center of the embankment. The core wall extends from the south abutment to 730 feet north of the gatehouse. The remaining earthfill is shown as gravel on the drawings. A cutoff of timber sheet piling extends a maximum of 13 feet below the base of the dam. The sheeting only exists from 130 feet south of the spillway to 100 feet north of the gatehouse. The side slopes of the embankment are 2:1 upstream and downstream.

Specifications for construction of the dam are not available.

There is no information on the shear strength or permeability of the soil and/or rock materials of the embankment.

A number of observation wells were originally placed along the downstream toe of the dam (described on page B-9). These could not be located during the field inspection.

6.3 Post-Construction Changes. Since the original construction of the dam, repairs were made to the stone masonry on the spillway and miscellaneous repairs made to the gatehouse in 1956. Also, one of the three original outlets in the gatehouse was replaced with a second water supply pipe.

6.4 Seismic Stability. The dam is located in Seismic Zone No. 2, and in accordance with Corps of Engineers' guidelines does not warrant further seismic analysis at this time.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. As a result of the visual inspection, the review of available data, and information on operation and maintenance, the dam is considered to be in good condition. However, due to the inability of the spillway to pass the peak test flood outflow without overtopping the dam, the project is classified in fair overall condition. The following deficiencies must be corrected to assure the continued performance of this dam: localized erosion next to the gatehouse and at the bend in the top of the dam; growth of large trees on the top and slopes of the dam near the north abutment; animal burrows on the downstream slope of the dam; and a heavy growth of trees and brush on the slopes of the dike.

The peak test flood (full PMF) outflow is estimated to be 13,100 cfs with the pond at El 187.1. The test flood would overtop the low point of the dam by 1.7 feet. Hydraulic analyses indicate that the spillway can discharge 4,650 cfs or 35 percent of the test flood outflow before the dam is overtopped.

b. Adequacy. The lack of detailed design and construction data did not allow for a definitive review. Therefore, the evaluation of this dam is based on a review of the available data, the visual inspection, past performance and engineering judgment.

c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within 1 year after receipt of this Phase I Inspection Report.

7.2 Recommendations.

It is recommended that the Owner employ a qualified registered engineer to perform a detailed hydrologic/hydraulic analysis to further assess the need for and means to increase the project discharge capacity and the ability to withstand overtopping. The Owner should implement the recommendations of the Engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. It is recommended that the Owner accomplish the following:

(1) Develop procedures for clearing trees, brush and roots from the dam and dike embankments, and to a distance of 25 feet from the downstream toe. All stumps and roots removed should be backfilled with select material.

(2) To prevent continued erosion, fill in and seed eroded areas on the top of the dam.

(3) Fill in existing animal burrows on the downstream slope of the dam south of the spillway. Continue to examine the embankment for new animal burrows and backfill any that appear.

(4) Institute a definite plan for surveillance of the dam and spillway during and after periods of heavy rainfall and a plan to warn people in downstream areas in the event of an emergency at the dam.

(5) Implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances and be supplemented by additional inspections during and after severe storms. All repairs and maintenance should be undertaken in compliance with all applicable State regulations. The maintenance program should include removal of any debris caught on the spillway weir to prevent clogging of the spillway.

(6) Institute a program of technical inspections of this dam on a biennial basis.

7.4 Alternatives. There are no practical alternatives to the above recommendations.

APPENDIX A

PERIODIC INSPECTION CHECKLIST

FOSS RESERVOIR DAM

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT FOSS RESERVOIR DAM

DATE December 5, 1980

TIME 9 AM-3 PM

WEATHER Clear & Cold

W.S. ELEV. 176.6* U.S. 162.2* D.N.S.

*based on benchmark at El. 179.59 on crest of spillway

Abbreviations:
D/S = Downstream
U/S = Upstream

PARTY:

1.	Ed Greco	Metcalf & Eddy, Inc.	Geotechnical
2.	Carol Sweet	Metcalf & Eddy, Inc.	Geotechnical
3.	Lyle Branagan	Metcalf & Eddy, Inc.	Hydraulics
4.	Bill Cheechi	Metcalf & Eddy, Inc.	Geotechnical
5.	Frank Gordon	Metcalf & Eddy, Inc.	Geotechnical
6.	Steve Cash	MDC	Assistant Foreman
7.			
8.			
9.			
10.			

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	Greco/Sweet	
2.	Dike	Greco/Sweet	
3.	Spillway	Greco/Sweet/Branagan	
4.	Gatehouse	Greco/Sweet/Branagan	
5.			
6.			

PERIODIC INSPECTION CHECK LIST

PROJECT FOSS RESERVOIR DAM DATE December 5, 1980

PROJECT FEATURE Dam Embankment NAME Ed Greco

DISCIPLINE Geotechnical NAME Carol Sweet

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	Varies from 185.4 to 186.0
Current Pool Elevation	176.6
Maximum Impoundment to Date	182.8 August 1955
Surface Cracks	None visible
Pavement Condition	N/A
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Relatively flat
Horizontal Alignment	Mostly straight with bend near north abutment
Condition at Abutment and at Concrete Structures	South abutment ties into Rte 9 roadway North abutment ties into natural ground
Indications of Movement of Structural Items on Slopes	None visible
Trespassing on Slopes	Tire ruts on top of dam & bike rut at bend-5 animal burrows 1" diam. on D/S slope of dam next to spillway.
Sloughing or Erosion of Slopes or Abutments	Erosion at top of U/S slope adjacent to gatehouse
Rock Slope Protection - Riprap Failures	Riprap is hand placed stone blocks in good condition-no failures-local growth of brush
Unusual Movement or Cracking at or near Toes	None visible
Unusual Embankment or Downstream Seepage	None visible
Piping or Boils	None visible
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None
Vegetation on Slopes	10 oak trees 2 ft. diam. on slopes + top of dam near north abutment-1 tree at downstream toe of dam near south abutment.

PERIODIC INSPECTION CHECK LIST

PROJECT FOSS RESERVOIR DAM DATE December 5, 1980

PROJECT FEATURE Dike Embankment NAME Ed Greco

DISCIPLINE Geotechnical NAME Carol Sweet

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	185.8 to 186.0
Current Pool Elevation	176.65
Maximum Impoundment to Date	182.80 August 1955
Surface Cracks	None visible-heavily overgrown
Pavement Condition	N/A
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Flat
Horizontal Alignment	Straight
Condition at Abutment and at Concrete Structures	Abutments tie into natural ground
Indications of Movement of Structural Items on Slopes	N/A - no structural items
Trespassing on Slopes	Tire ruts in top of dike
Sloughing or Erosion of Slopes or Abutments	None visible
Rock Slope Protection - Riprap Failures	Hand placed cut stone riprap on U/S slope-heavily overgrown-no visible failures
Unusual Movement or Cracking at or near Toes	None visible
Unusual Embankment or Downstream Seepage	None visible
Piping or Boils	None visible
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None
Vegetation on Slopes	U/S and D/S slopes heavily overgrown with brush + small trees; many 2 ft. diam. trees within 10 ft. of D/S toe.

PERIODIC INSPECTION CHECK LIST

PROJECT FOSS RESERVOIR DAM DATE December 5, 1980

PROJECT FEATURE Spillway NAME Ed Greco/Carol Sweet

DISCIPLINE Geotechnical NAME Lyle Branagan

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Submerged
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	3:1 slope paved with mortared stone
b. Weir and Training Walls	
General Condition of Concrete	Good-slight efflorescence on D/S face
Rust or Staining	None
Spalling	None
Any Visible Reinforcing	N/A
Any Seepage or Efflorescence	Slight efflorescence from mortar on D/S face - few open joints
Drain Holes	None visible
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Minor - along edges of channel
Floor of Channel	Natural streambed
Other Obstructions	35'x13'Rectangular opening Under Rte 9 400 ft. D/S of dam

PERIODIC INSPECTION CHECK LIST

PROJECT FOSS RESERVOIR DAM **DATE** December 5, 1980

PROJECT FEATURE Gatehouse **NAME** Ed Greco

DISCIPLINE Geotechnical **NAME** Carol Sweet

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	Constructed of mortared stone blocks
General Condition	Good
Condition of Joints	N/A
Spalling	N/A
Visible Reinforcing	N/A
Rusting or Staining	None
Any Seepage or Efflorescence	None visible
Joint Alignment	N/A
Unusual Seepage or Leaks in Gate	Submerged
Cracks	None
Rusting or Corrosion of Steel	Gate mechanisms are good-painted and no visible corrosion
b. Mechanical and Electrical	
Air Vents	One in peak of roof
Float Wells	None-water level read manually in wet well using staff gauge
Crane Hoist	None
Elevator	None
Hydraulic System	None
Service Gates	Four on outlets
Emergency Gates	Five on water supply pipes
Lightning Protection System	None visible
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	None

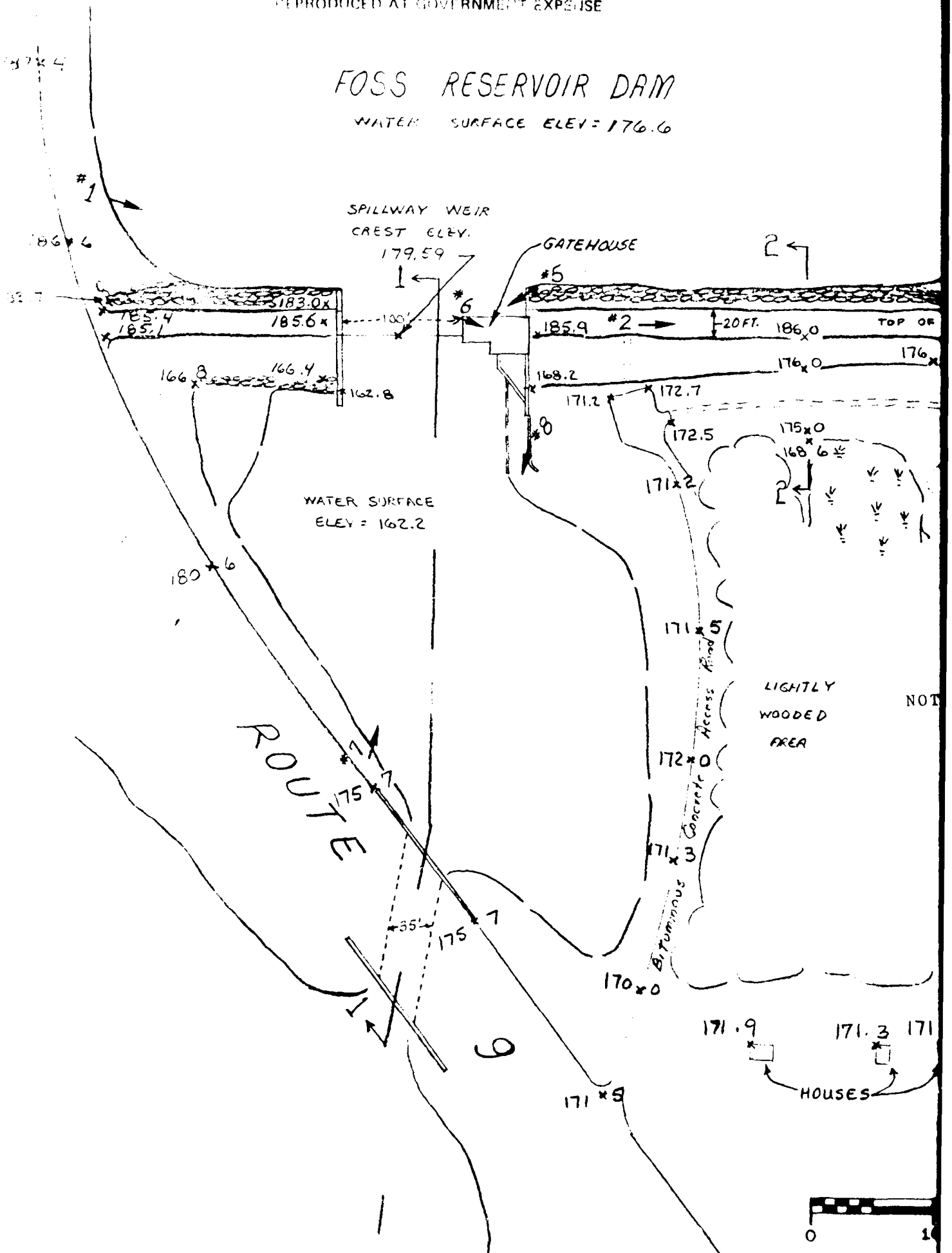
APPENDIX B

PLANS OF DAM AND PREVIOUS
INSPECTION REPORTS

REPRODUCED AT GOVERNMENT EXPENSE

FOSS RESERVOIR DAM

WATER SURFACE ELEV = 176.6



METCALF & EDDY IN

INSPECTION REPORT - DAMS AND RESERVOIRS

(1.) Location: ~~City~~/Town FRAMINGHAM Dam No. 4-9-100-5

Name of Dam SUDBURY RIV. RESERV. #3 Inspected by A.Z. PIZANO F.H. PARE

Date of Inspection 7-25-

(2) Owners: per: Assessors ✓ Prev. Inspection ____

Reg. of Deeds ____ Pers. Contact ____

1. [redacted]

Name	St. & No.	~~City~~/Town	State	Tel.
M.D.C.	20 SOMERSET ST.	BOSTON, MASS - 02114		727-5215

2.

Name	St. & No.	City/Town	State	Tel.

3.

Name	St. & No.	City/Town	State	Tel.

(3) Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name	St. & No.	City/Town	State	Tel.
SAME				

(4) No. of Pictures taken NONE

(5) Degree of Hazard: (if dam should fail completely)*

1. Minor ____ 2. Moderate ____

3. Severe ✓ 4. Disastrous ____

*this rating may change as land use changes (future development)

(6) Outlet Control: Automatic ____ Manual ✓

Operative ✓ yes: ____ no.

Comments: SLUICE GATES MAINTAIN WATER FLOW THROUGH SPILLWAY TO ALLOW 0.5' FLOW OVER DAM SLUICE GATES ARE IN GATE HOUSE (5'x5'

(7) Upstream Face of Dam: Condition:

1. Good ✓ 2. Minor Repairs ____

3. Major Repairs ____ 4. Urgent Repairs ____

Comments:

A number of pipes were also placed in the ground below the dam, on a line generally parallel with it, for the purpose of observing the level of the underground water and the direction of its flow. The observations made by means of these pipes have always shown that the surface of the water underground slopes uniformly from the extremities of the dam towards the brook.

All the aprons and all the sheet-piling about them were, like the foundations, built by day labor; they are substantially as has been described for Dam No. 1. All the work built by the city by day labor was done during the working season of 1876 and 1877.

The material used for refilling the trenches and for forming the up-stream side of the banks was composed of various materials, clayey sand, gravel, and loam, often mixed together and carefully compacted; the compact, clayey material, from the "Homer's" hill, was used exclusively for the first 10 feet adjacent to the masonry wall on the up-stream side.

The down-stream slopes are made of gravel.

In clearing the ground north of the gate-house for the embankment, a deep layer was found, of loam and other material, mixed with roots and unsuitable for forming embankments; a large amount was dumped below the embankment, forming a heavy berme under which the surface soil has not been removed; the rest of the waste material was dumped in a swamp below the dam.

The overflow and the masonry work generally (Plates 4, 5, and 6) is built in the same manner as that of the other dams. The overflow is 100.25 feet long. The elevation of the crest of the dam is 175.24.

The gate-chamber contains: —

First. The end of one branch of the 48-inch pipe connected with Dam No. 1.

Second. Six gates, 5 ft. × 4 ft.,[1] placed at 2 different levels, and controlling the 3 chambers, through which the water flows from Reservoir No. 3 to Reservoir No. 1.

Third. Three gates, one 4 ft. × 5 ft.,[1] and two 4 ft. × 4.5 ft.,[1] for regulating the flow into the 48-inch pipe.

Fourth. A floating gauge indicating the height of water in the reservoir.

A house is built over the gate-chamber.

The 48-inch pipe, after leaving the gate-chamber, is protected from the action of the water by a heavy wall, laid in cement mortar, and, farther from the dam, by a rough wall, laid dry, and by riprapping.

below the level of the meadow. Owing to the compactness of the sand the piles went down very slowly under the hammer; for the last 5 or 6 feet the advance was frequently less than ¼ inch at each blow. The progress was so slow and the blows were so frequent that, at two different times, a pile was extracted with much effort, to judge of its condition. In both cases they were found entirely uninjured by the driving.

From the end of the sheet-piling at Station 8 + 09, the centre-wall has been built several feet into the compact sand underlying the superficial stratum of gravel of various thickness, which is found all along the line; at Station 9 + 40 the sand, in which the wall is built, is less compact, and remains so as far as the first angle formed by the line of the dam: there the sand of the foundation becomes compact again until Station 12 + 60, where coarse material is encountered, in which the centre-wall terminates at Station 14 + 35. At that point the embankment is reduced in width at the top from 20 to 10 feet.

From Station 14 + 35 to Station 19 + 24 no centre-wall has been laid, and the embankment is only a few feet above the natural ground. North of the old turnpike the gravel being found very coarse, it was feared that water would percolate freely through it at a point where the ridge forming the edge of the reservoir is narrow; consequently a wall, 3 feet in thickness and 300 feet long, was built through the gravel into the sand, underlying it to a depth varying from 18 to 22 feet below the top of the embankment. Further north, with the exception of a place where a shallow embankment has been built without any other precaution than that of removing the loam from its base, the dam is formed by the natural wide ridge, which extends from the old turnpike towards the railroad track. From this description and from the examination of the plates it may be seen that in several parts of this structure walls have been built to a considerable depth through the ground, where the base of the natural embankment forming the dam is broad enough to insure perfect safety; but the nature of the material was such that it was thought advisable to make that expenditure, in order to avoid too abundant percolations. The event has justified the course followed, for at several places, mainly at the south end of the dam, near the new road, in the portions extending north of the gate-house to the old turnpike, and north of the latter, the water is filtering through the porous strata of the gravelly ridges which form a portion of the dam. The water, which thus finds its way from the reservoir, is collected in Basin No. 1.

With the expectation that some percolation would take place through the gravel strata surrounding the various portions of the dam, two weirs were erected, before filling Reservoir No. 3, for the purpose of measuring it. Some additional weirs were put up afterwards. The water which found its way through the ground was concentrated and made to pass over these weirs, where daily measurements were made. Since the filling of Reservoir No. 1, three of those weirs have been permanently kept, and the volume of water passing over them has been observed. The amount of water which flows through the ground increases regularly with the height of the reservoir, but remains nearly uniform for the same heads; since the time of construction it has slightly diminished. When considering the large area of gravelly surfaces directly exposed to the water pressure, and the comparatively small amount of water which finds its way through them, it is evident that the velocity with which this water flows through the ground is so small that it cannot carry with it any solid matter. It is always found perfectly clear, and free from earthy particles in suspension.

The fluctuation allowed between the crest of the dam and the high-water mark, in reference to which the seizure has been made, is 1½ feet; it must be limited, in time of freshets, by the opening of the gates, which have been given, for that purpose, a very large area.

The capacity of the reservoir, when full, is 1,074,200,000 gallons.

(For the capacities corresponding to various heights of water in the basin, see Appendix.)

The gates at Dam No. 3 were closed for the first time on December 3, 1878, to let the water rise in the reservoir, the flow of the brook being then large; on December 11, at 10.30 P.M., the water passed for the first time over the crest.

DAM NO. 3.

The plans and specifications for Dam No. 3 were approved by the County Commissioners of Middlesex on June 6, 1876.

Dam No. 3 is formed of various sections, and extends in a general northerly direction across the valley of Stoney Brook, on the (formerly) Homer and Freeman farms. (For stationing, etc., see Appendix.)

The foundation of this dam is built entirely on sand and gravel. A portion of the dam, not represented on Plate No. 3, is formed by the new Worcester turnpike, and by an irregular embankment connected with it, which encloses a small area of flowage on the *Homer* estate. The high-water mark at this point was about one foot only above the natural surface of the ground; care was taken, however, to remove all the loam from the base of the road and of the adjoining embankment, and, as the strata underlying the loam were, especially under the road, of porous sand and gravel, a puddle wall made of gravel, compact, clayey sand, and loam, was built in the middle of the road and in the heart of the adjoining embankment, to a depth of 7 feet below high-water mark in the reservoir. This puddle bank, where it strikes at a right angle the centre wall of the main dam, forms a close connection with it by dividing in two branches enclosing a spur projecting from the wall.

The centre wall, built on the main line of the dam, starts at Station 2 + 25, about 70 feet south of the new turnpike. It extends in a straight line almost true north for 854 feet, and then bends to the right. The first strata found are of gravel and coarse sand, through which the masonry is built to a depth of 21 feet below the surface. Under the road the gravel is much coarser, and from there to Station 3 + 50 the wall is built to a depth of about 33 feet below the surface; it enters then a stratum of fine, gritty sand, which it follows as far as the overflow; the latter is built in the same material; the gate-house and the centre wall beyond it, as far as Station 9 + 10, are built in a very fine, bluish sand.

From Station 4 + 25 to Station 8 + 09, the front of the masonry of the centre-wall, of the overflow and of the gate-chamber is protected by a heavy sheet-piling 8 in. in thickness, tongued and grooved, driven with much care. At the overflow the bottom of the sheet-piling extends 13 feet below the bottom of the masonry, which stands itself 15 feet

RESERVOIR NO. 3.

This reservoir is the largest of the three now built; it extends in the valley of Stoney Brook from Dam No. 3, which limits the northerly arm of Reservoir No. 1, in a general north-westerly direction, across the track of the Old Colony R.R. (formerly the Boston, Clinton, & Fitchburg R.R.), to a point on the stream a little beyond the boundary line of Framingham and of Southborough. The land covered by this reservoir is entirely of a farming description.

As the top of the railroad embankment extending through the valley occupied by the reservoir was too near the high-water mark, it became necessary to raise the grade of the track, and to rebuild the bridge over Stoney Brook. By mutual agreement the Railroad Company raised its embankment, widened it sufficiently for the accommodation of a proposed second track, and built a new bridge, 50 feet in span, over the bed of Stoney Brook; it assumed also all the risks arising from the construction of the reservoir.

The city, by the payment of damages to the Railroad Company, acquired the right of flowage over its bank and of maintaining the reservoir, "provided the height of the overflow at the dam, be it formed by stone coping, or by flash-boards, or in any other manner, is not above elevation 176.5 above tide marsh level" (*i.e.*, 1.26 above the present granite coping), "and provided the height of the embankments of the dam are not above elevation 181.5." (It is at present 181.32.)

The old Worcester turnpike crossed the valley now occupied by the reservoir; several roads were surveyed to take its place; finally the County Commissioners ordered the present one, with an iron bridge 35 feet in span over Stoney Brook. (For date of location, etc., see Appendix.)

The seizure of land made by the commissioners for the road, instead of embracing, as usual, a strip of uniform width, includes irregular areas, such as are sufficient to contain the embankments and cuts.

The portions of the embankments which are in the reservoir are paved to a line above the high-water mark.

It must be remembered that several hundred feet of this road form a portion of the embankment of the reservoir, *and must be kept to conform to its requirements.*

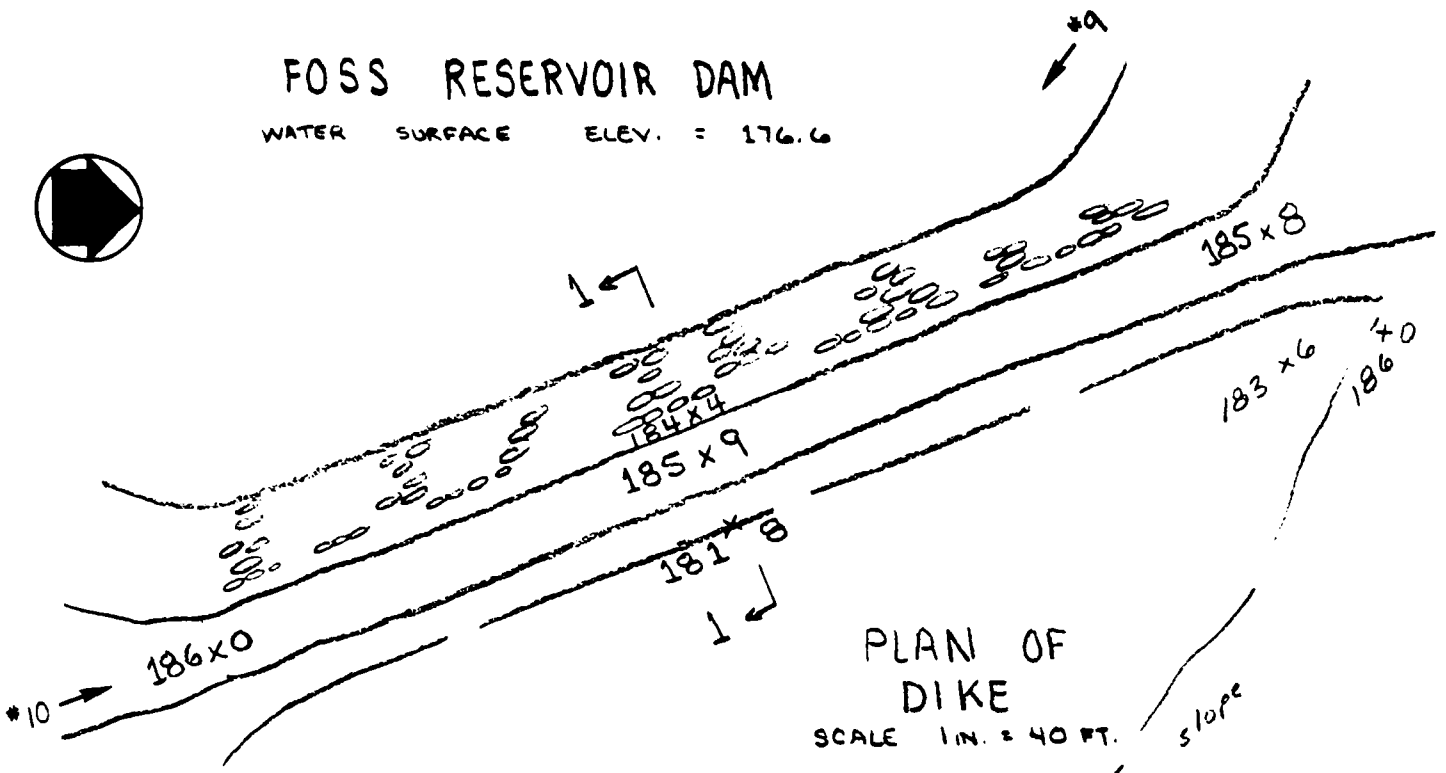
A small portion of the old Southborough road, near the house of W. P. Temple, was raised and straightened, and a culvert was built under it to accommodate the brook coming from the estate of Dr. P. Parker.

All the brush and wood growing on the location of the reservoir was cleared, in 1877, to the high-water line.

The depth of Reservoir No. 3, at the dam, is 25 feet. It is nearly as deep for all the portion of the basin south of the railroad, with the exception of the borders and of an extensive gravel ridge which extends diagonally across the reservoir. The depth north of the railroad diminishes gradually towards the end.

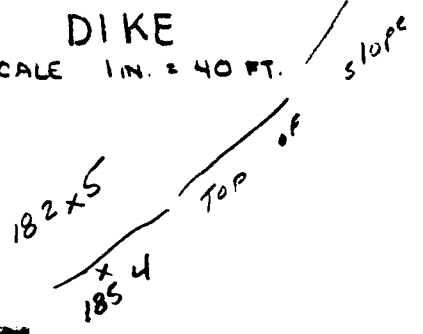
FOSS RESERVOIR DAM

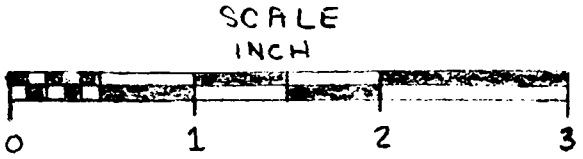
WATER SURFACE ELEV. = 176.6

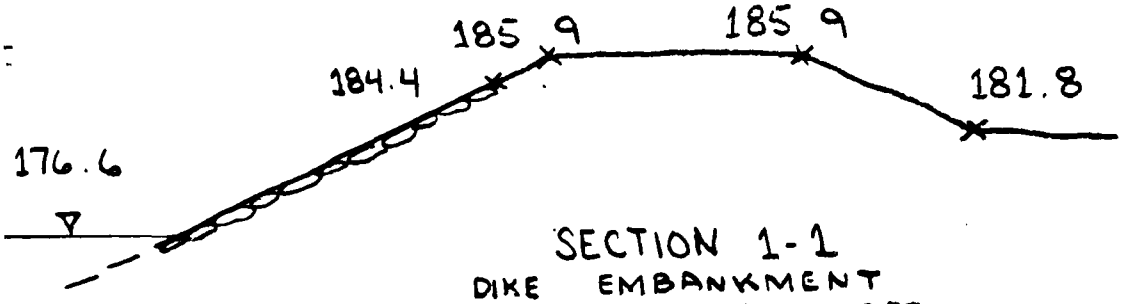


PLAN OF DIKE

SCALE 1 IN. = 40 FT.







SECTION 1-1

DIKE EMBANKMENT

HORIZ SCALE 1 IN = 10FT

VERT SCALE 1 IN = 10FT

NOTE:

1. Elevations shown based on spillway crest elevation 179.59 (NGVD) taken from the Metropolitan District Commission records.
2. Information shown based on field inspection of December 5, 1980.
3. ↗ No. 2 indicates location and direction of view for photographs.

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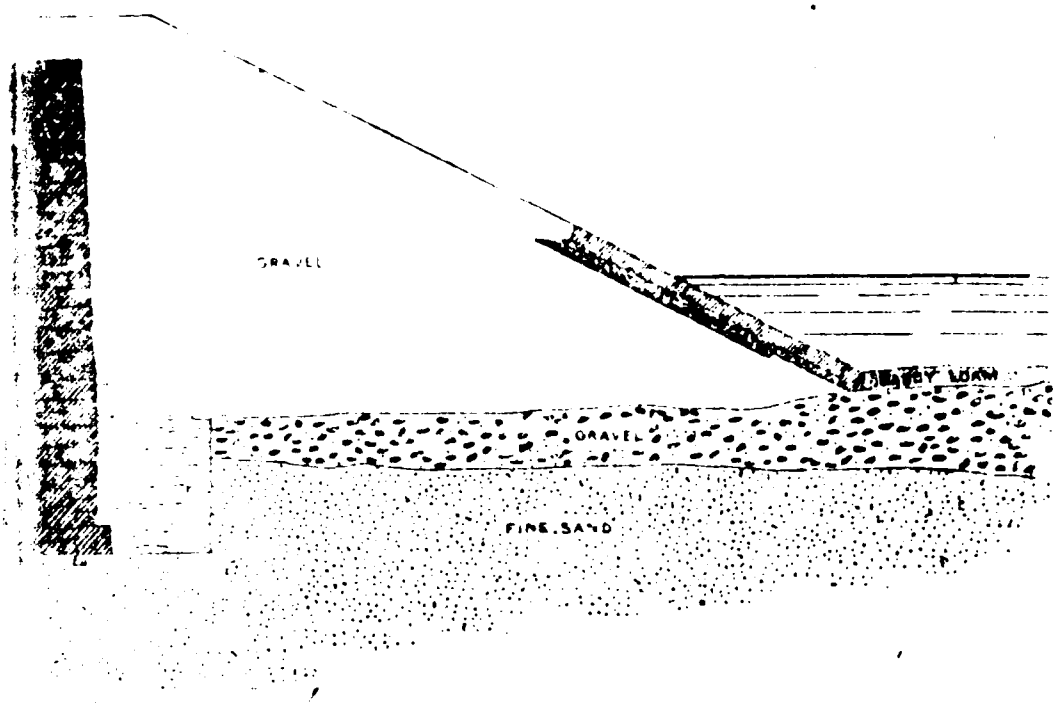
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
FOSS RESERVOIR DAM	
FIGURE B-6 DIKE AND DIKE SECTIONS	
TRIBUTARY MERRIMACK RIVER	MASSACHUSETTS
SCALE: AS SHOWN	DATE: DECEMBER, 1980

REPRODUCED AT GOVERNMENT EXPENSE

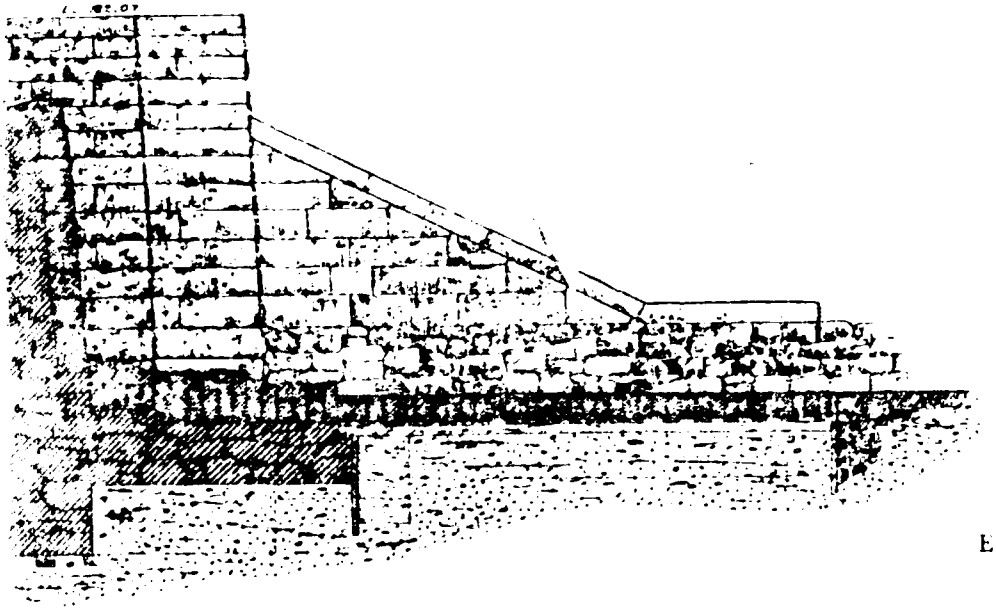
NO. 3.

SECTIONS



5+40

Dam III



N ON CD

FIGURE B-4

Extract of book plate from

"Additional Supply
from Sudbury River"

by Boston Water Works
1882

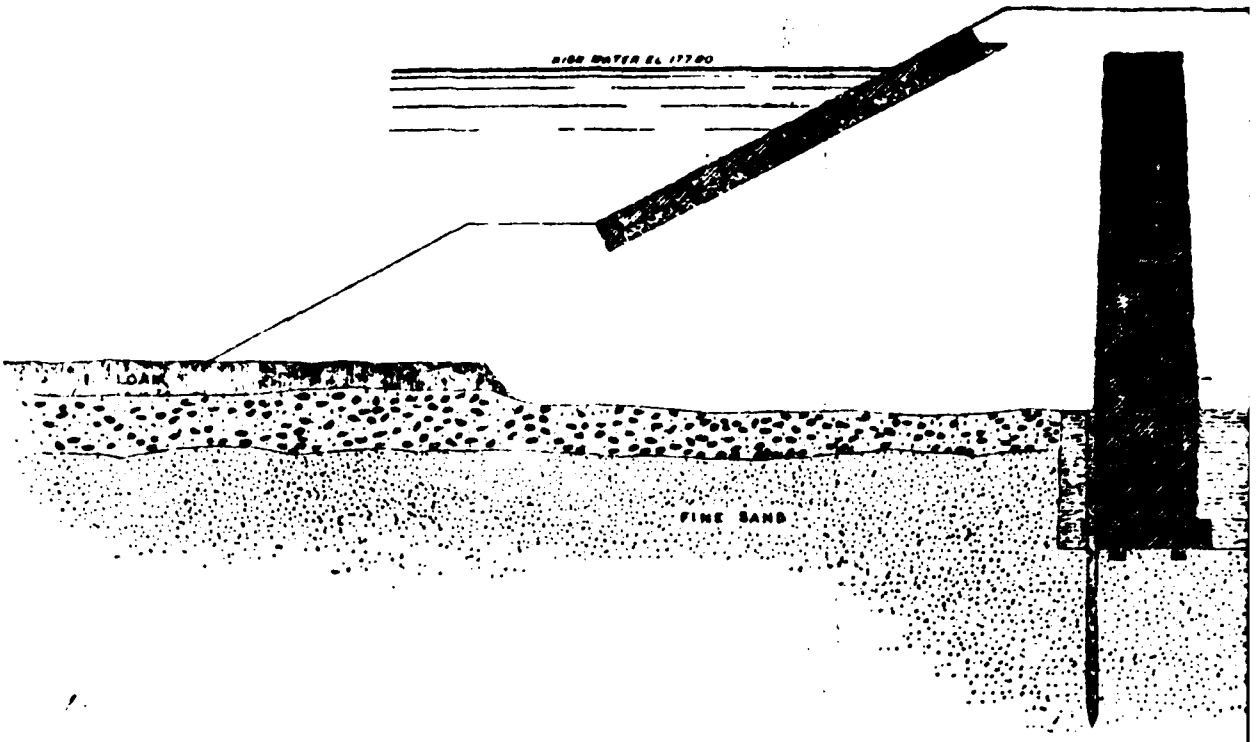
SCALES AS NOTED

REPRODUCED AT GOVERNMENT EXPENSE

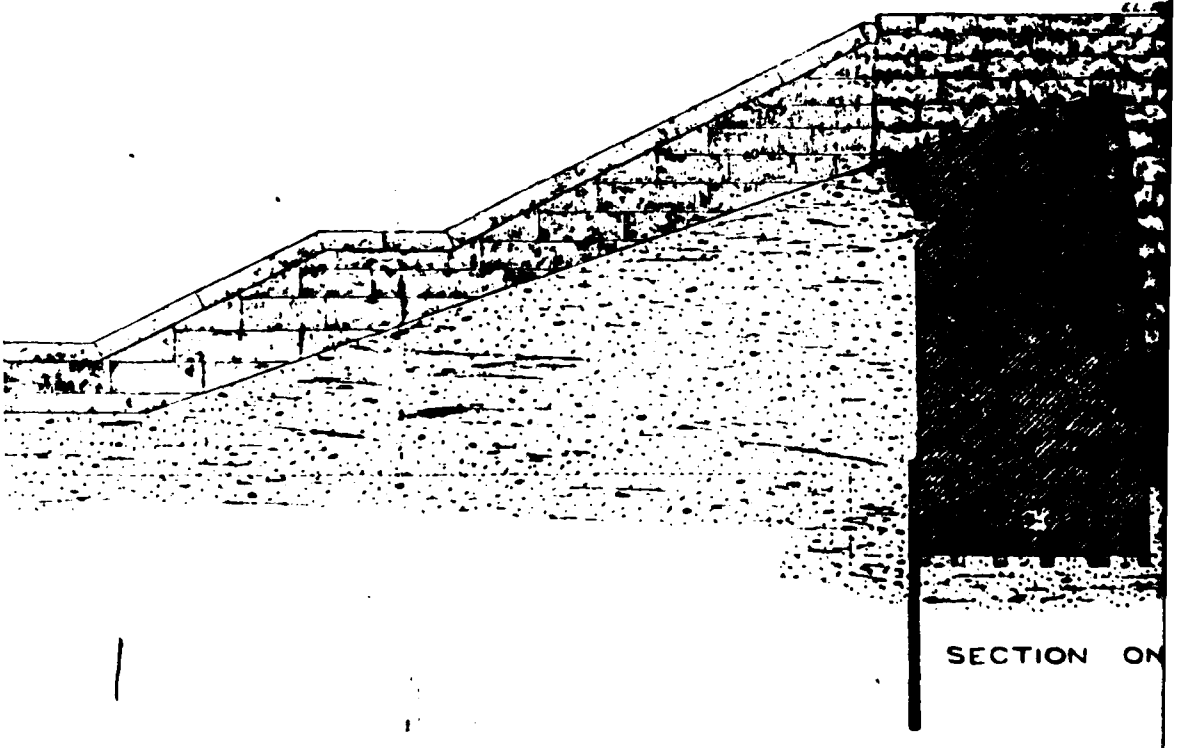
DAM NO.

CROSS SECTIO

Scale of feet



STA. 5+40.



SECTION ON

REPRODUCED AT GOVERNMENT EXPENSE

N

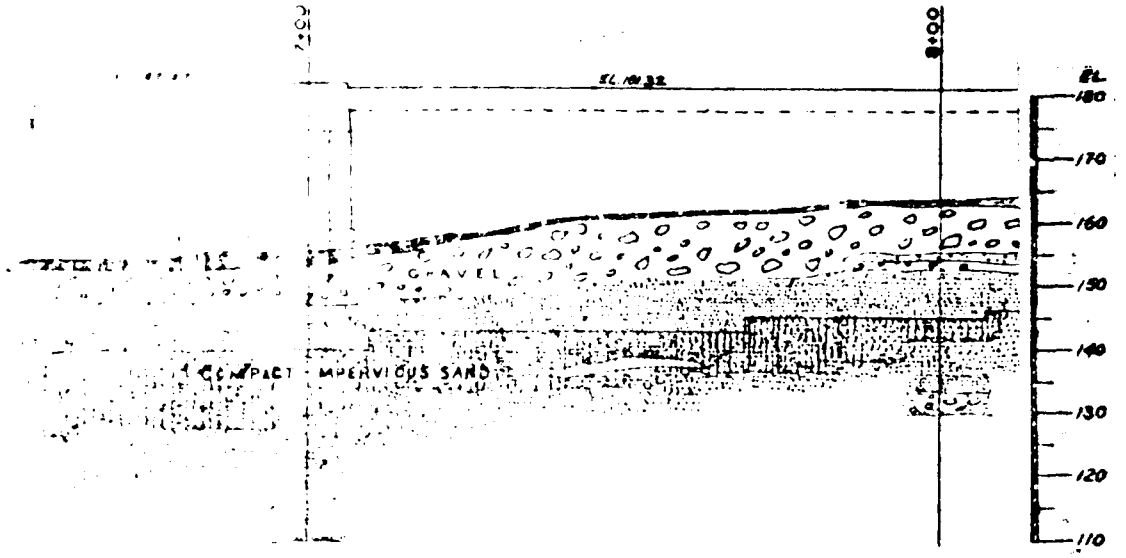


FIGURE B-3

Extract of book plate from
"Additional Supply
from Sudbury River"
by Boston Water Works
1882
SCALES AS NOTED

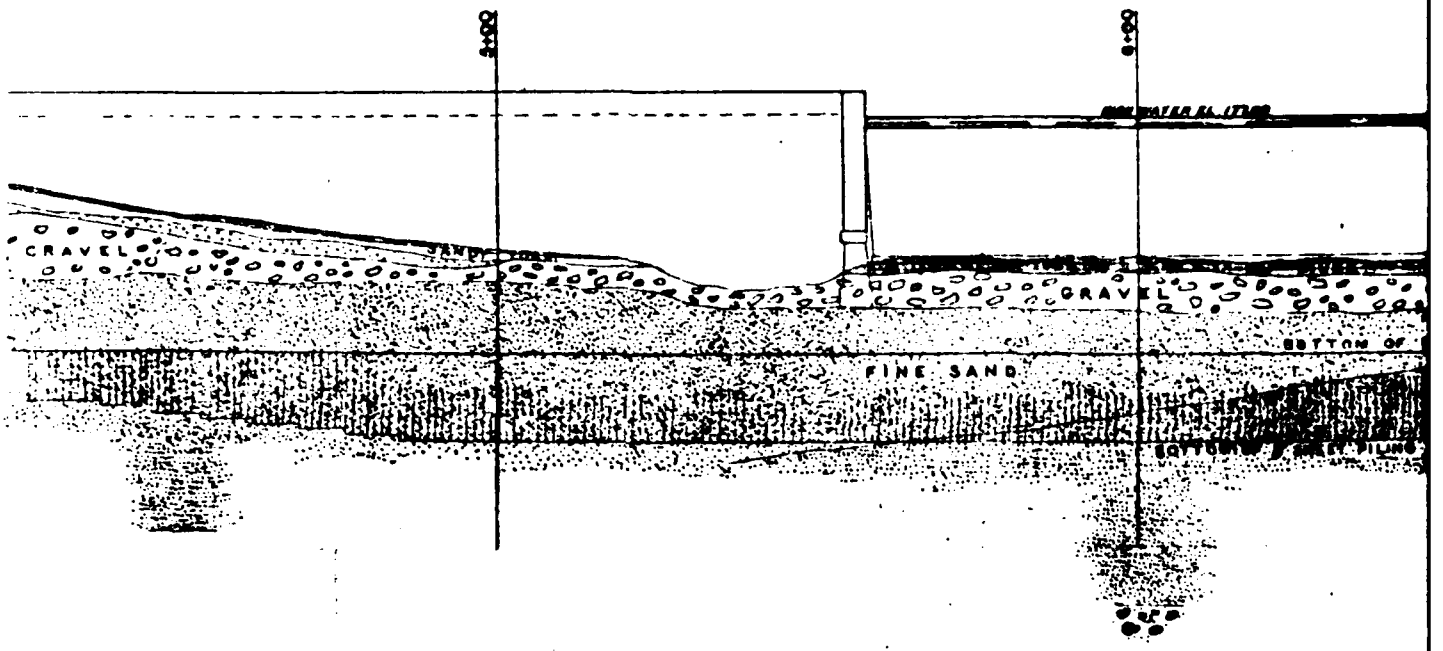
12

REPRODUCED AT GOVERNMENT EXPENSE

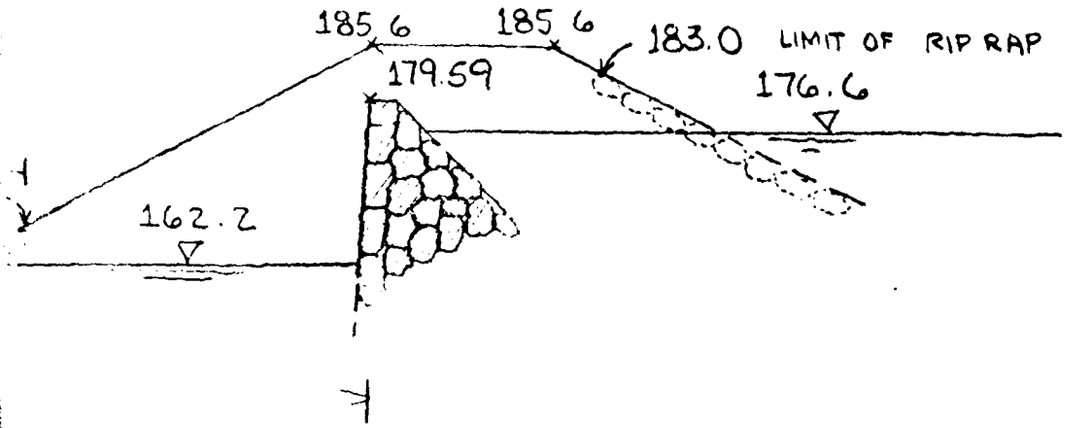
DAM NO. 3

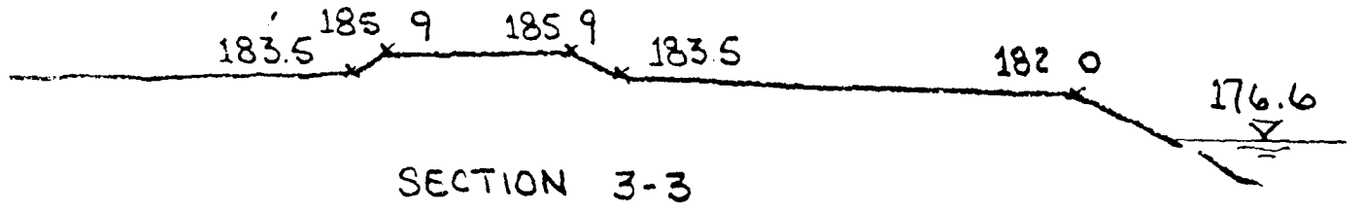
LONGITUDINAL SECTI

SHOWING FORMATIO



REPRODUCED AT GOVERNMENT EXPENSE





SECTION 3-3

DAM EMBANKMENT

HORIZ SCALE 1 IN = 20FT

VERT SCALE 1 IN = 2FT

NOTE:

1. Elevations shown based on spillway crest elevation 179.59 (NGVD taken from the Metropolitan District Commission records.

2. Information shown based on field inspection of December 5, 1980.

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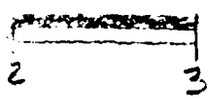
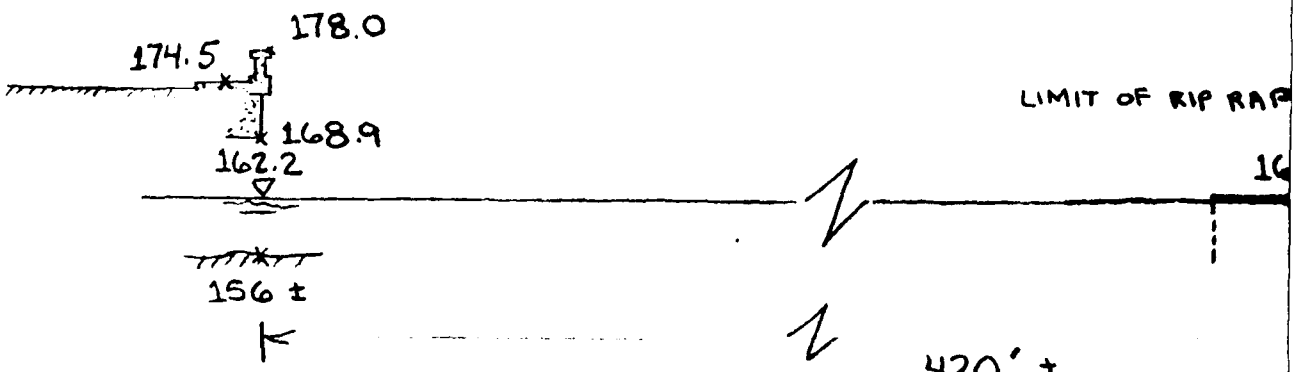
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
FOSS RESERVOIR DAM	
FIGURE 3-2 SECTIONS THROUGH DAM	
TRIBUTARY MERRIMACK RIVER	MASSACHUSETTS
SCALE: AS SHOWN	DATE: DECEMBER, 1980



2

REPRODUCED AT GOVERNMENT EXPENSE

ROUTE 9

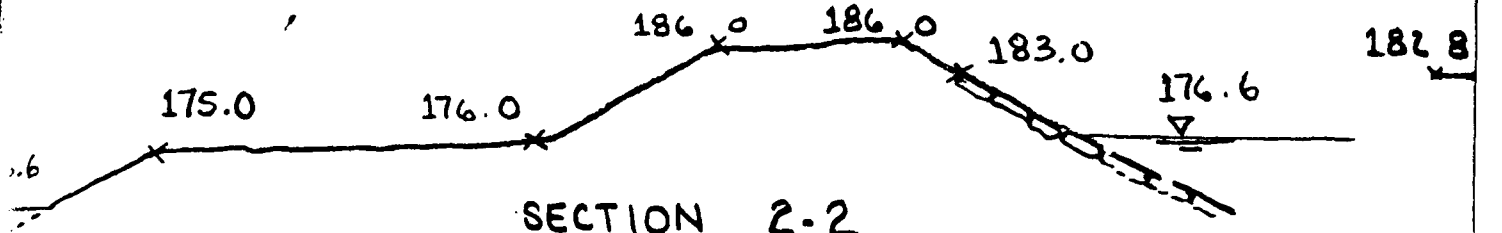


SECTION 1-1

SPILLWAY TO ROUTE 9

HORIZ. SCALE 1 IN = 20FT

VERT. SCALE 1 IN = 2 FT

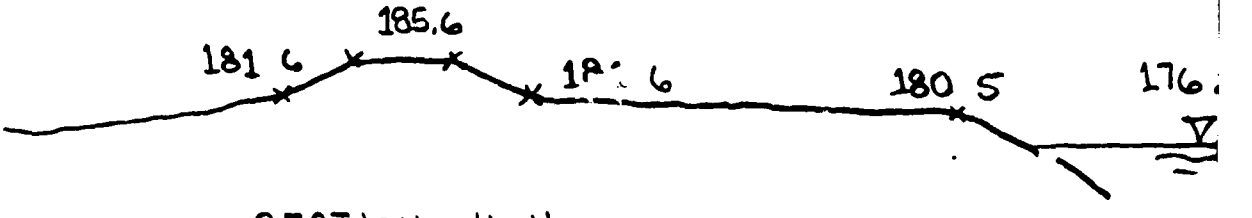


SECTION 2-2

DAM EMBANKMENT

HORIZ SCALE 1 IN = 20FT

VERT SCALE 1 IN = 2 FT

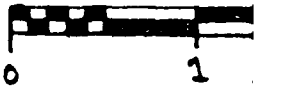


SECTION 4-4

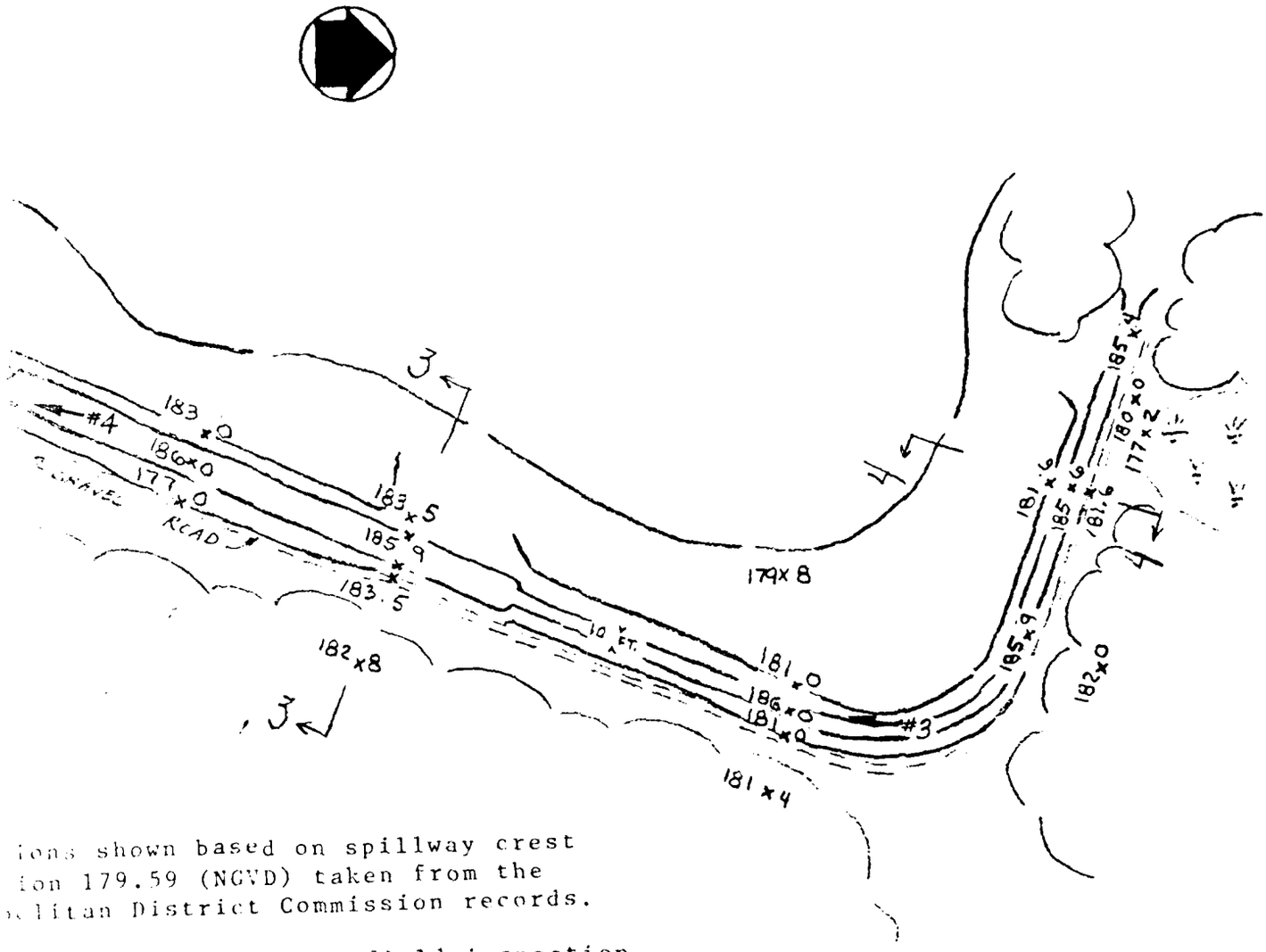
DAM EMBANKMENT

HORIZ SCALE 1 IN = 20FT

VERT SCALE 1 IN = 2 FT



REPRODUCED AT GOVERNMENT EXPENSE



ions shown based on spillway crest
ion 179.59 (NGVD) taken from the
olitan District Commission records.

ation shown based on field inspection
ober 5,1980.

icates swampy area.

indicates location and dire tion of
or photographs.

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NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

FOSS RESERVOIR DAM

FIGURE 8-1 PLAN OF DAM

TRIBUTARY MERRIMACK RIVER	MASSACHUSETTS
SCALE: 1" = 100'	DATE: DECEMBER, 1980

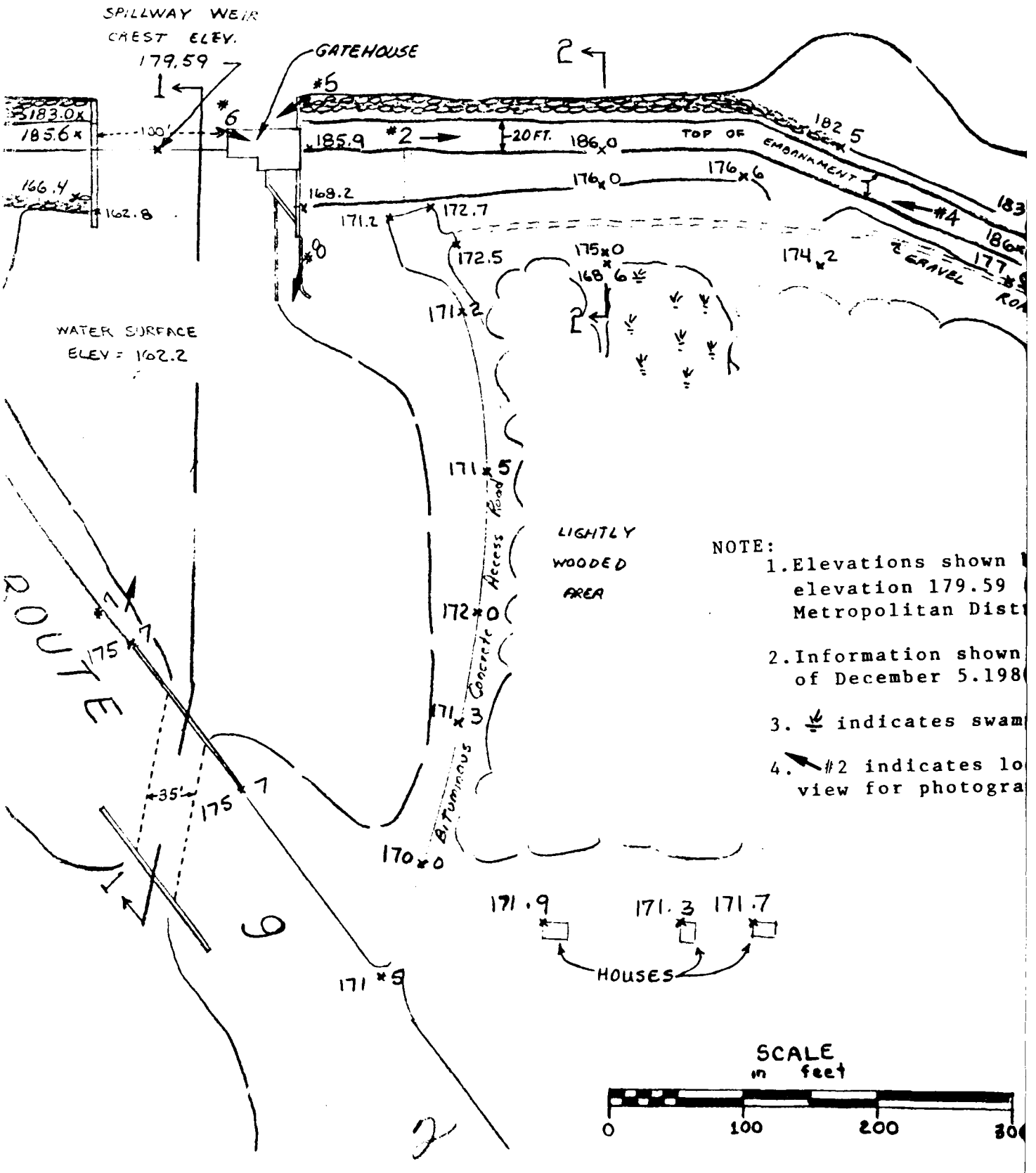
200 300

3

REPRODUCED AT GOVERNMENT EXPENSE

FOSS RESERVOIR DAM

WATER SURFACE ELEV = 176.6



NOTE:

1. Elevations shown ... elevation 179.59 ... Metropolitan Dist...
2. Information shown ... of December 5.198...
3. ⸸ indicates swam...
4. #2 indicates lo... view for photogra...

DAM NO. 4-9-100-5

(8) Downstream Face of Dam: Condition: 1. Good ✓ 2 Minor Repairs____

3. Major Repairs____ Urgent Repairs_

Comments:_____

(9) Emergency Spillway: Condition: 1. Good ✓ 2. Minor Repairs_____

3. Major Repairs____ 4. Urgent Repairs___

Comments:_____

(10) Water level @ time of inspection 5 ft. above_____ below ✓

top of dam ✓ Principal spillway_____

other_____

(11) Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment_____

Animal Burrows and Washouts_____

Damage to slopes or top of dam_____

Cracked or Damaged Masonry_____

Evidence of Seepage_____

Evidence of Piping_____

Erosion_____

Leaks_____

Trash and/or debris blocking flow_____

Clogged or blocked spillway_____

Other NO DEFICIENCIES NOTED

DAM NO. 4-9-100-5

(12.) Remarks & Recommendations: (Fully Explain)

DAM IS IN GOOD CONDITION.

(13.) Overall Condition:

1. Safe ✓
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____.
5. Reservoir impoundment no longer exists (explain)

Recommend removal from inspection list _____.

DESCRIPTION OF DAM
DISTRICT #4

Submitted by FRANCIS H. PARÉ & ADAM Z. PIZAN Dam No. 4-9-100-5
Date 7/25/73 City/Town FRAMINGHAM 0170
Name of Dam RESERVOIR #13

1. Location: Topo Sheet No. 26C
Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: 1900 Year/s of subsequent repairs /

3. Purpose of Dam: Water Supply ✓ Recreational ___
Irrigation ___ Other ___

4. Drainage Area: 3 SQ. MI., 1920 ACRES.

5. Normal Ponding Area: 300 Acres; Ave. Depth 24'
Impoundment: 2400 MIL gals; 7,200 acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir
i.e. summer homes etc. 5 APARTMENTS & 1000 PERMANENT HOMES, ADJACENT TO RESERVOIR

7. Dimensions of Dam: Length 100' Max. Height 20'
Slopes: Upstream Face VERT
Downstream Face "
Width across top 15'

8. Classification of Dam by Material:
Earth ✓ Concrete Masonry ✓ Stone Masonry ✓
Timber ___ Rockfill ___ Other ___

9. a. [illegible] of present land usage downstream of dams 10 % rural
90 % urban
b. [illegible] storage area or flood plain downstream of dam which could handle the impoundment in the event of a complete dam failure
No ✓ Yes ___.

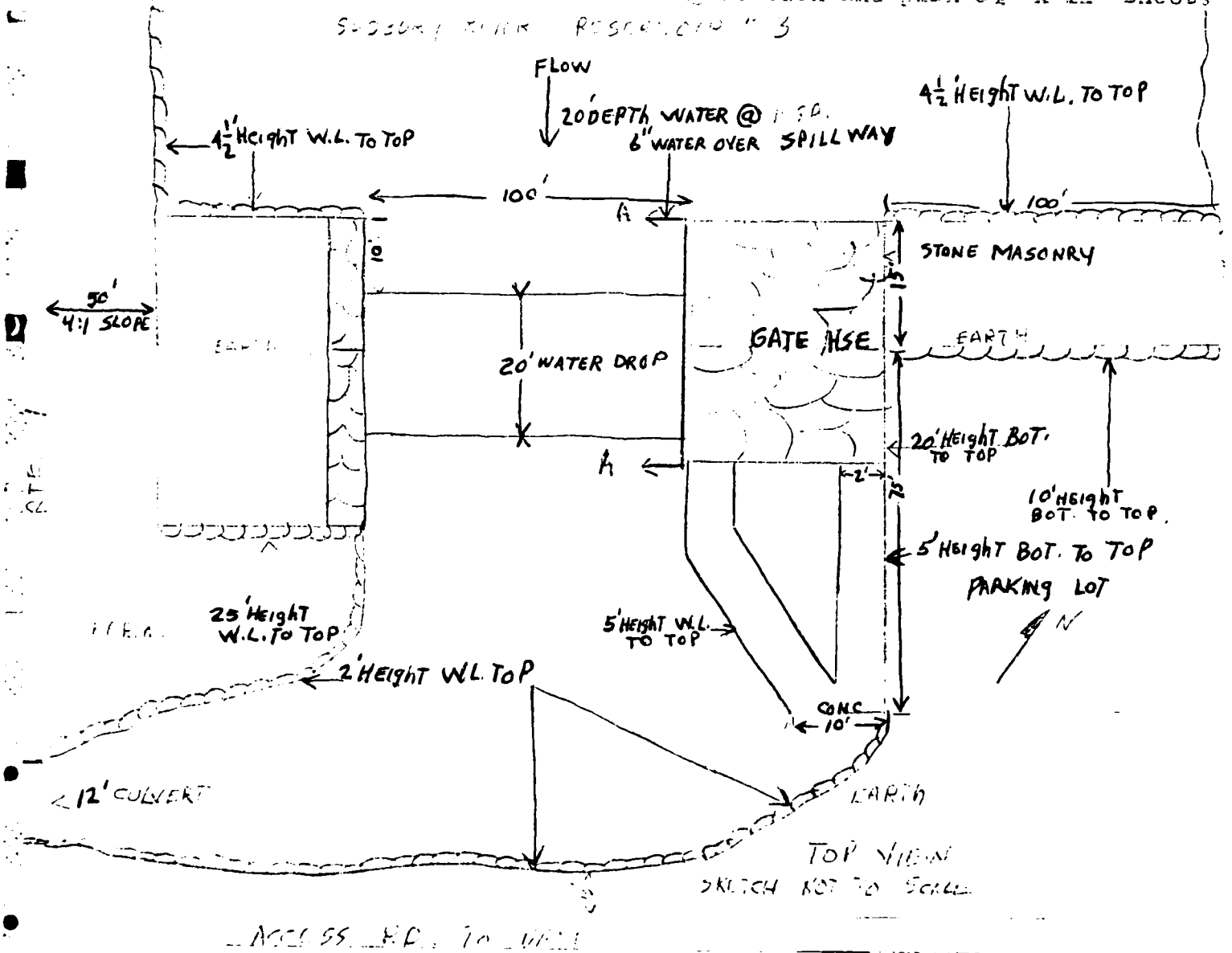
  FOSS RESERVOIR DAM

DAM NO. 4-9-100-5

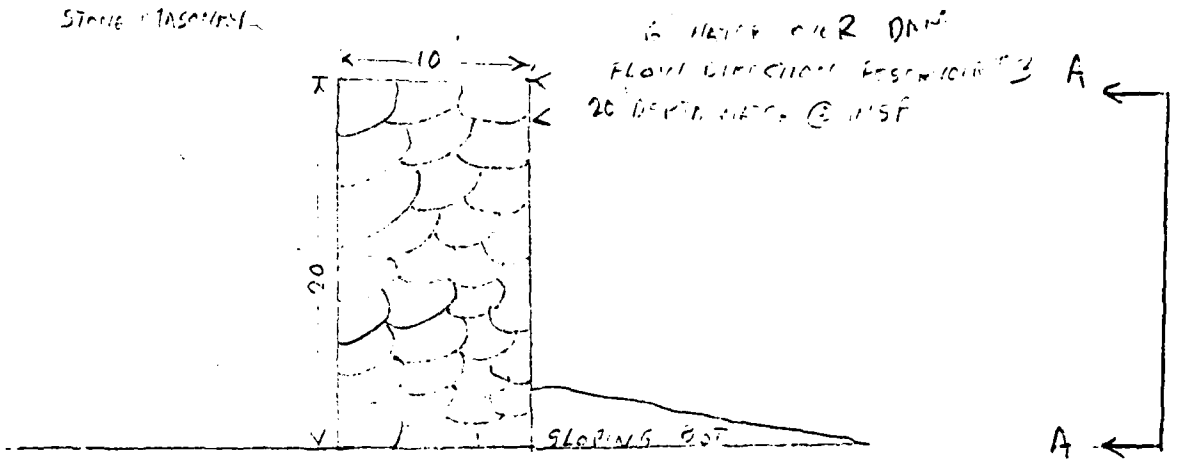
10.
Risk to life and property in event of complete failure.

No. of people NONE
No. of homes "
No. of businesses "
No. of industries " Type
No. of utilities " Type
Railroads "
Other dams "
Other "

11.
Sketch of dam to be used for showing portion and plan 8½" x 11" Sheet.



4-9-100-5



X SECTION AA

SKETCH NOT TO SCALE

APPENDIX C

PHOTOGRAPHS

Note: Location and direction of photographs shown on Figures B-1 and B-5 in Appendix B

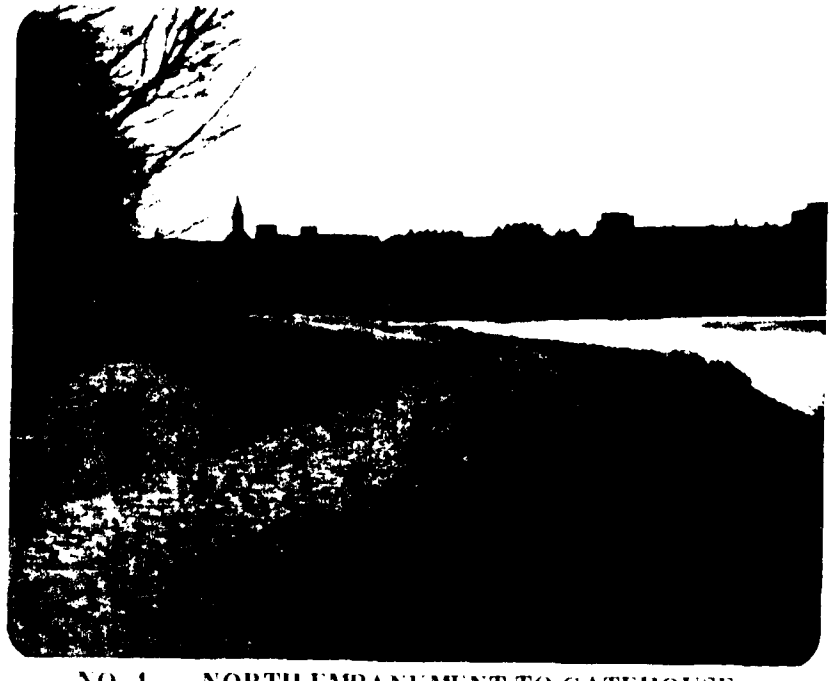
REPRODUCED AT GOVERNMENT EXPENSE

NO. 1 GATEHOUSE AND SPILLWAY NEAR SOUTH ABUTMENT OF DAM

NO. 2 TOP OF UPSTREAM SLOPE OF DAM NORTH OF GATEHOUSE

REPRODUCED AT GOVERNMENT EXPENSE

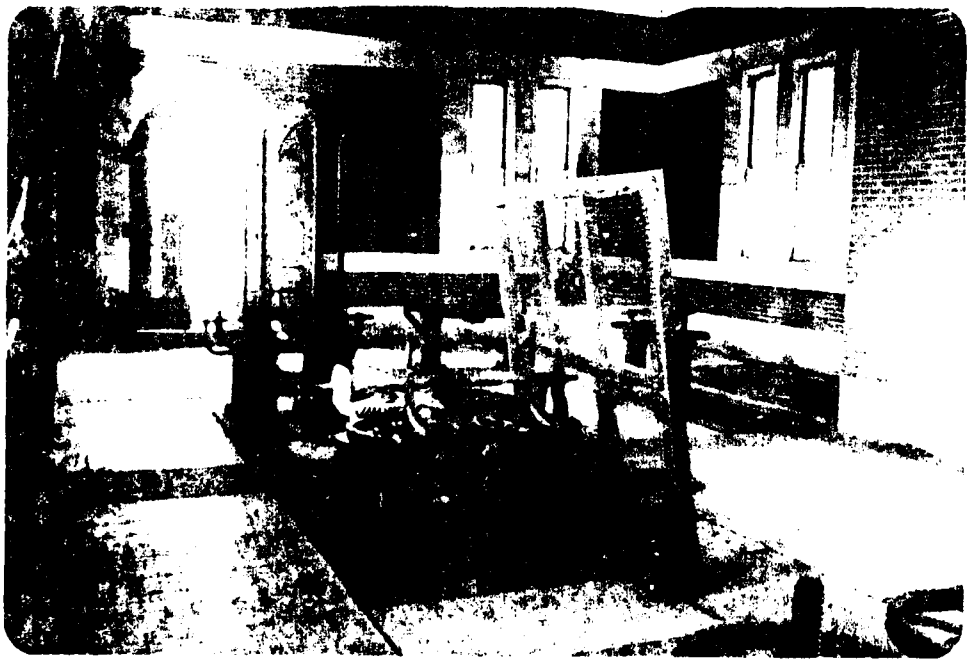
NO. 3 EMBANKMENT NEAR NORTH ABUTMENT



NO. 4 NORTH EMBANKMENT TO GATEHOUSE

REPRODUCED AT GOVERNMENT EXPENSE

NO. 5 UPSTREAM OPENINGS INTO WET WELL OF GATEHOUSE

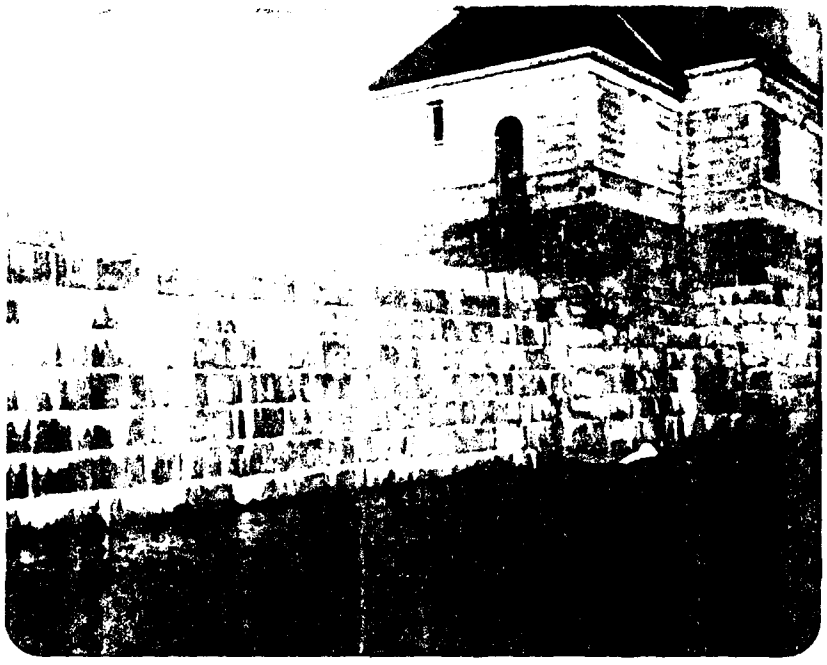


NO. 6 INTERIOR OF GATEHOUSE AND SLUICE GATE MECHANISMS

REPRODUCED AT GOVERNMENT EXPENSE

NO. 7 POND BELOW DAM

NO. 8 EMBANKMENT AND BRIDGE FOR ROUTE 9



NO. 9 DOWNSTREAM FACE OF SPILLWAY

NO. 10 DETAIL OF EROSION NEXT TO GATEHOUSE

REPRODUCED AT GOVERNMENT EXPENSE

NO. 11 UPSTREAM SLOPE OF DIKE

NO. 12 TOP OF DIKE

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

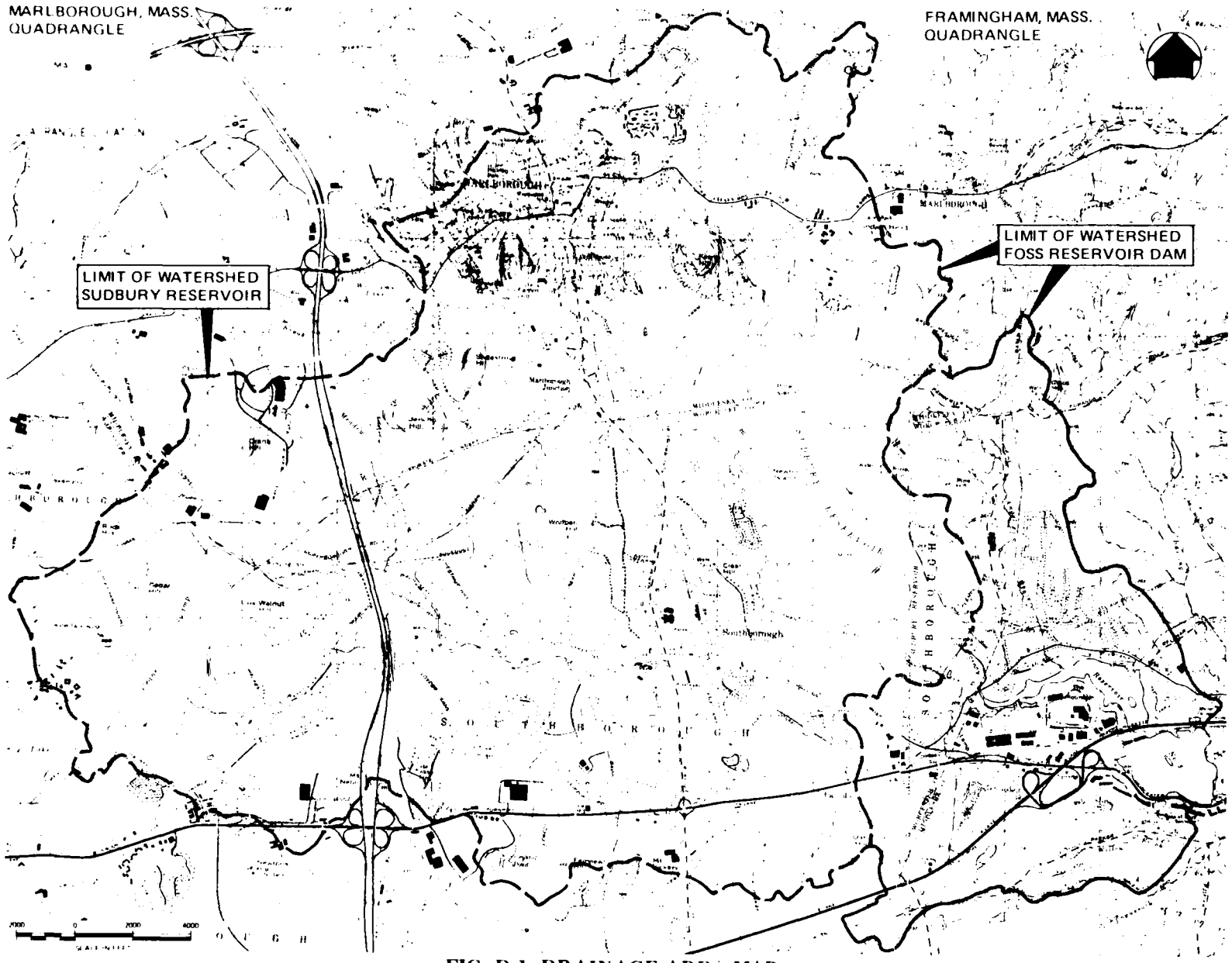


FIG. D-1 DRAINAGE AREA MAP

METCALF & EDDY

NONREPRODUCIBLE GRID FORM 145

METCALF & EDDY, ENGINEERS

Forward:

The drainage area of Foss Res. No. 3 is 27.6 sq. mi. Of this area, 22.3 sq mi is also tributary to Sudbury Res., which has had a Phase I evaluation.

The maximum, full PMF discharge from Sudbury Res. was estimated to be 11,100 cfs, and to occur approximately 4 hours after the peak inflow, in the Phase I evaluation, by others.

The drainage area directly tributary to Foss Res. No. 3 is 5.3 sq mi. The peak PMF flow from this area alone is 6890 cfs (see (I)).

Based on the existing Phase I evaluation of Sudbury, the outflow at the 2nd hour is ±2000 cfs. Adding this to the direct runoff peak gives a peak inflow toward the Foss No. 3 spillway of 8890 cfs (Full PMF conditions) This is the initial peak, est. to occur 3.6 hours after start of storm.

3.8 hours later the Sudbury peak of 11,100 cfs will inflow to Foss No. 3. The local runoff has been estimated to be 2000 cfs at that time for a total peak inflow of 13100 cfs. (see (II)). Since this is the maximum estimated inflow rate, it will be taken as the Test Flood Inflow.

NONREPRODUCIBLE GRID FORM 145

METCALF & EDDY, ENGINEERS

(I) Test Flood, Storage & Storage Function for Direct Drainage Area

1- Total Drainage Area - 5.3 mi²

2- Pond(s) Area: .01 + .01 = .02 mi²
Swamp(s) Area: .01 + .05 + .06 + .06 = .18
Total Area Pond(s) & Swamp(s): .20 mi²

$$\% \text{ Ponds \& Swamps} = \frac{0.20}{5.3} = 3.8\%$$

3- $\frac{464-179}{15900} = .01792$; $\frac{397-179}{14200} = .01535$ } Say Ave Slope = 1.7%

4- Using C. of E. Curves for Peak Flow Rates & above guide values the Peak Flow Rate was estimated to be between "Rolling" and "Flat & Coastal" and taken at 1300 c.f.s./mi²
Size Class: Interm.; Hazard Pot.: High; Spill. Des. Flood: Full PMF
Use: Test Flood = Full PMF

5- **Test Flood Inflow = (5.3) 1300 = 6890 c.f.s.**

6- Pond Storage
The pond area is 0.36 sq. mi. at elev. 179±. Based on a const. area, storage increases at 230.4 ac. feet per foot of depth increase.

7- Spillway crest elev. is 179.59

8- Storage Functions are based on $Q_{out} = Q_{in}\left[1 - \frac{S_{out}}{R}\right]$
S_{out} = Storage Vol. in Reservoir related to final Q_{out} in terms of inches of rain over the drainage area.

S(in Inches) $= 12\,D\left(\frac{0.36}{5.3}\right) = .815\,D$; R = 6hr rain of storm
D = Storage depth in feet above spillway crest in reservoir

9- Storage Functions: (Test Flood & ½ PMF - if needed)

$F'_{TF} = 6890^{*} - 362.6\,S = 6890^{*} - 295.6D$
$F'_{½PMF} = 3445^{*} - 362.6\,S = 3445^{*} - 295.6D$

* Add Sudbury disch. of 2000 cfs - full PMF or 1000 cfs - ½ PMF

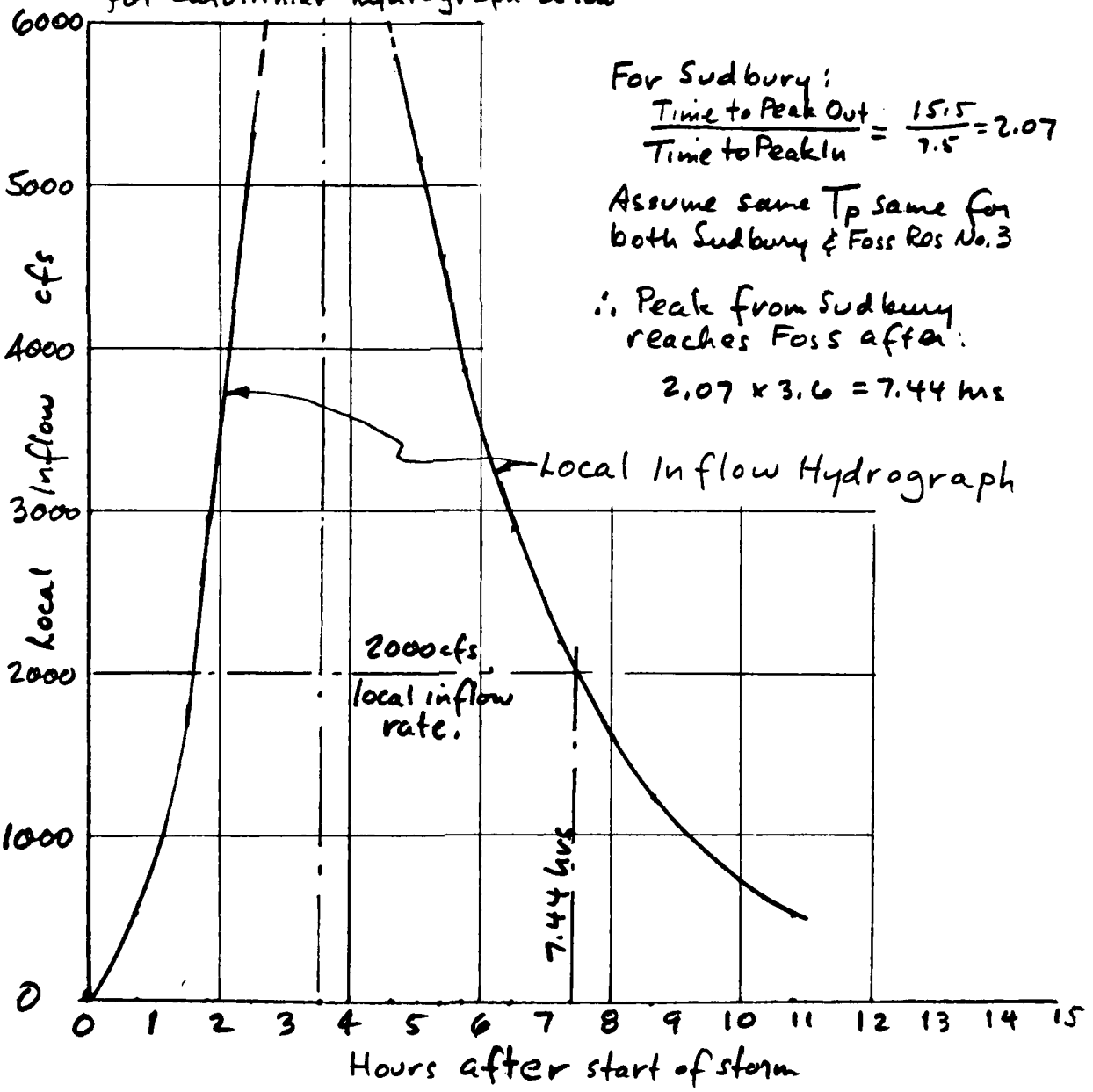
(II) Local Flow to Combine w/ Peak Sudbury Discharge

$D = 6$ hr. ; Longest run 15900' = 3.01 mi w/ 285' drop, $T_c = \left[\frac{11.9(3.01)^3}{285}\right]^{.385}$

$T_c = 1.05$ hr $\simeq 1.0$ hr. ; $T_p = \frac{D}{2} + 0.6T_c = 3.6$ hr.

$Q_p = 6890$ cfs ; $T_B = 2.67\, T_p = 9.6$ hr.

Use Fig 32 - "Des. of Sm. Dams", U.S.B.R., 1977 edition for curvilinear hydrograph below



For Sudbury:

$\frac{\text{Time to Peak Out}}{\text{Time to Peak In}} = \frac{15.5}{7.5} = 2.07$

Assume same T_p same for both Sudbury & Foss Res No. 3

∴ Peak from Sudbury reaches Foss after:

$2.07 \times 3.6 = 7.44$ hrs

NONREPRODUCIBLE GRID FORM 145
METCALF & EDDY, ENGINEERS

(III) Discharge Relations

A- Spillway

$L = 100'$, $C = 3.33$ (sharp edged ±), $Q_A = 333\ H_A^{1.5}$, Crest el. 179.59

Res. El.	180	182	184	185	185.4	186	187	186.5
H_A	.41	2.41	4.41	5.41	5.81	6.41	7.41	6.91
Q_A	90	1250	3080	4190	4660	5400	6720	6050

B. Crest Flow

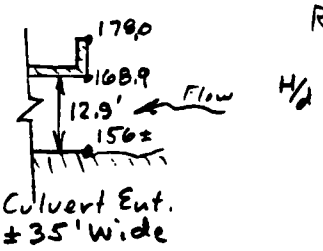
$L = 250'$ south + $1300'$ north + $150'$ dike = $1700'$
$Q_B = 2.55(L)\ H_B^{1.5} = 4335\ H_B^{1.5}$; Ave crest el. 185.8;
L.P. Crest 185.4

Res El.	180	187	188	186.5	187.5
H_B	.2	1.2	2.2	.7	1.7
Q_B	390	5700	14150	2540	9610

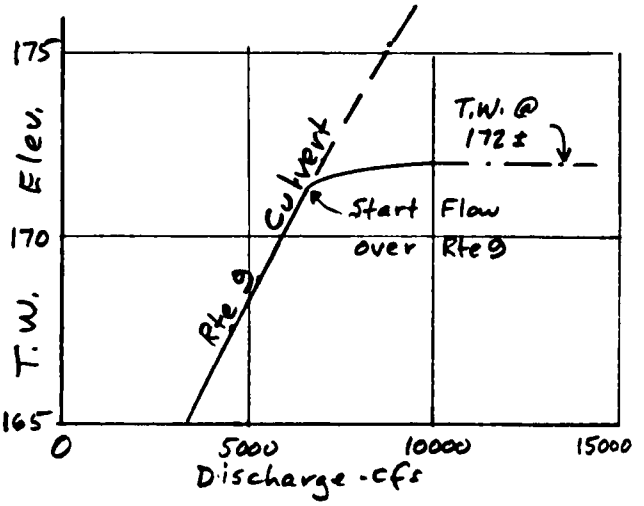
C - Tailwater

Tailwater levels are the levels of Res. No. 1 (just dnstr.) as modified by flow thru the Rte 9 and Salem Rd culverts For simplicity assume "entrance control" at the Rte 9 culvert sets the tailwater level

Ref.: V.T. Chow "Open-Chan. Hydr", pg 498, Fig. 17-29



H/d	0.9	1.0	1.25	1.5	2.0
Wat. El.	167.6	168.9	172.1	175.3	181.8
q	130	150	200	250	300
Q	4550	5250	7000	8750	10500



Note: When T.W. reaches el. 171.5 ± flow will start to pass over Rte 9. Assume sizeable flow increase does not raise el. T.W. above 172 ±.

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(III) Discharge Relations (Cont.)

D - Gate House

Note: Assume T.W. el. ≅ 172 (Spill. + Gt. Hse flow > 10000 cfs)

1 - Discharge Ports - 4 @ 4'x5' - all submerged - use ΔH

$\Delta H = 1.5 \frac{V^2}{2g}$; $V = 6.55\sqrt{\Delta H}$; $Q_D = 4(20)6.55\sqrt{\Delta H} = 524\sqrt{\Delta H}$

Res. El.	180	182	184	185	185.4	186	186.5	187	179.59
ΔH	8	10	12	13	13.4	14	14.5	15	7.59
Q_D	1480	1660	1820	1890	1920	1960	1990	2030	1440

2 - Service Pipes - 2-48"ϕ pipes feed a dnstr. aquaduct. A nominal $Q = 2 \times A_{48} \times \pm 12$ fps = 300 cfs. Flow in pipes controlled by dnstr. conditions, which could prevent any significant flow during major storm. Pipes will be assumed to be inoperable during flood.

(IV) Low Level Outlet

Res @ el. 179.59, T.W. @ el. 165±

2 - 4'x5' openings @ el. 169.34; 2-4'x5' openings submerged.

$Q_A = 393\sqrt{H_A}$; $Q_B = 393\sqrt{\Delta H_B}$

Res El.	179.59	178.59
H_A	10.25	9.25
ΔH_B	14.59	13.59
Q_A	1258	1195
Q_B	1501	1449
ΣQ	2759	2644

Ave Q = 2700 cfs

Time to Lower Res. 1 ft = $\frac{230.4(43560)}{2700(3600)} = 1.03$ hours

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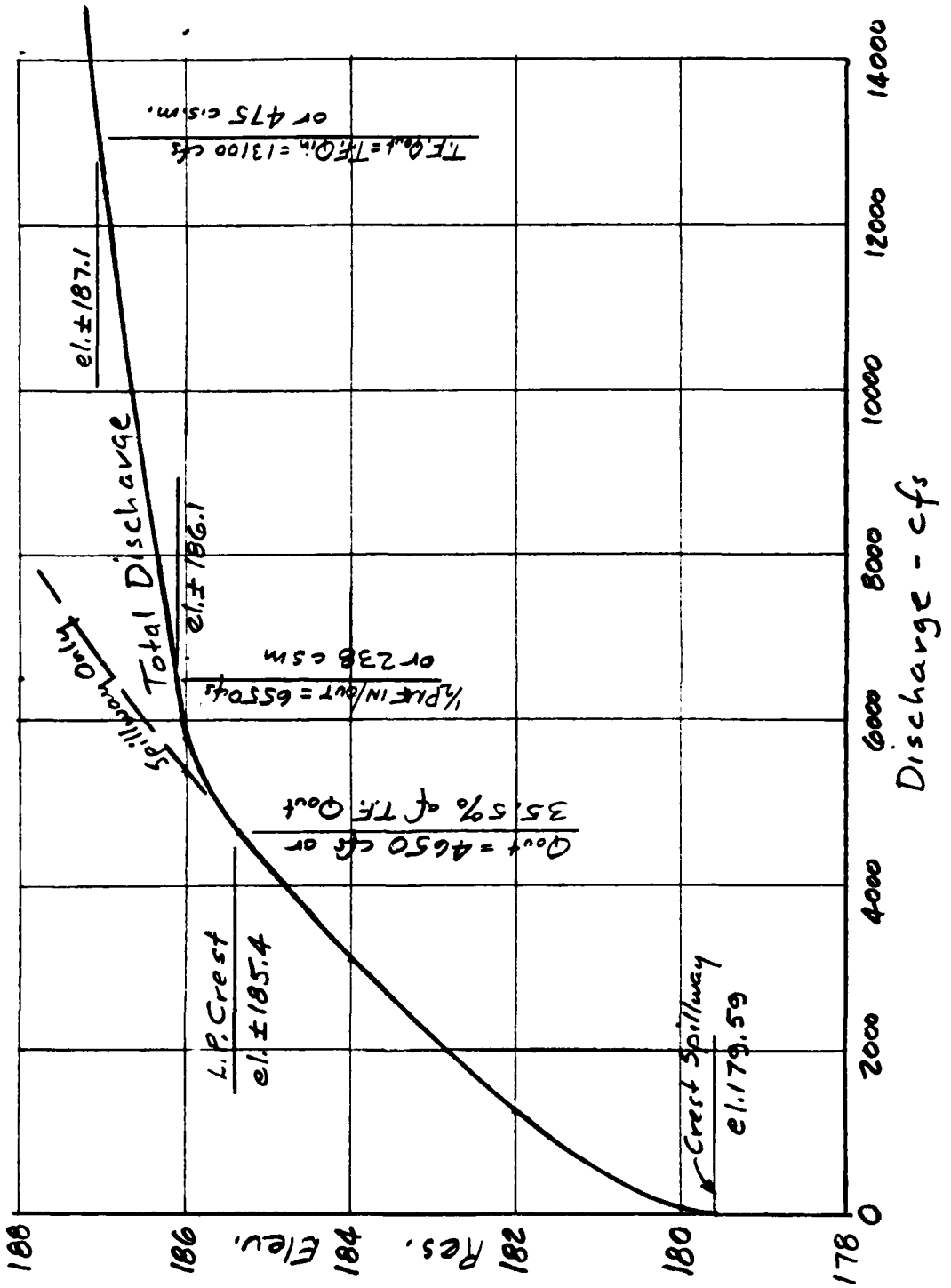
(V) Discharge vs Res. Elev. w/ Test Flood - Gate House Shut



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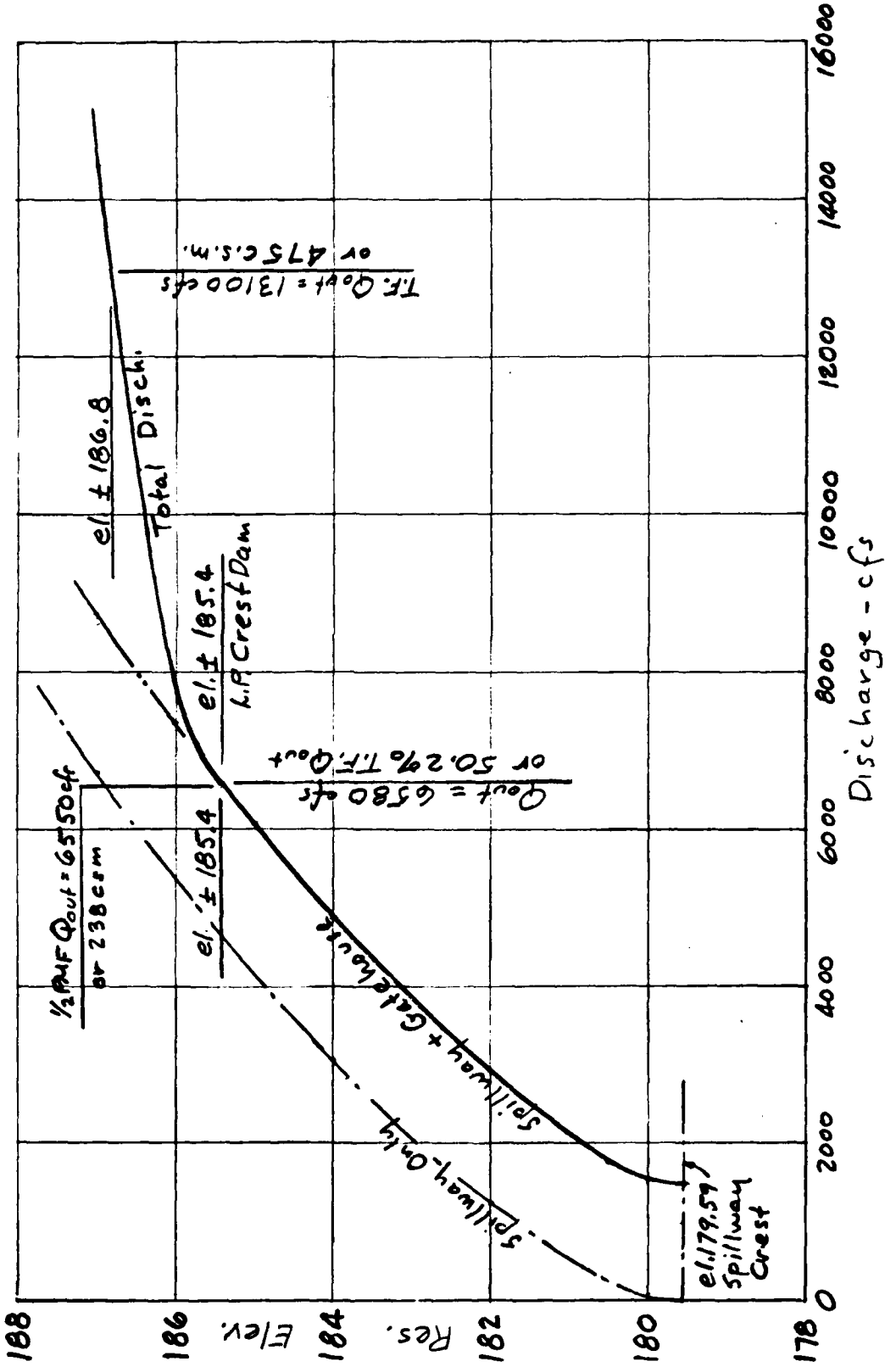
Project Nat. Review of Non Federal Dams Acct No. 7252 Page 7 of 10
Subject Middlesex County, Mass Comptd By LEB Date 1/7/80
Detail FOSS RESERVOIR NO.3 Ck'd By [illegible] Date 1-14-81

(VI) Discharge vs Res. El. w/Test Flood - Gate House Open



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VII Crest Flow

1- Gate House Shut

Peak T.F. Elev.	187.1
L.P. Crest Elev.	185.4
Max. Head.	1.7 feet

Unit Flow = $q = 2.55(1.7)^{1.5} = 5.65$ cfs/ft

As critical flow:

$y_c = \left(\frac{q^2}{g}\right)^{1/3} = 1.0$ ft ; $V_c = 5.7$ fps.

2- Gate House Open

Peak T.F. Elev.	186.8
L.P. Crest Elev.	185.4
Max. Head	1.4 feet

Unit Flow = $q = 4.2$ cfs/ft.

As critical flow:

$y_c = 0.8$ ft. ; $V_c = 5.1$ fps

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(VIII) # Failure of Dam

Peak Failure Flow:

Pond Elevation - 185.4 Low Pt. elev.
Toe Elevation — 168 ± Toe dam in swamp - left side of spillway
Y_o = 17.4

Dam Length Subject to Breaching ≅ 450'

$W_o = 40\%(450) = 180$ ft.

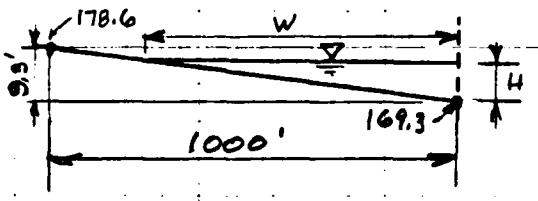
$Q_{P_1} = 1.68\, W_o (Y_o)^{1.5} = 1.68(180)(17.4)^{1.5} \cong 21950$ cfs.

Continuing Spill. Disch.: 4650 cfs
Peak Failure Flow: 26600 "

Storage Volume Released:

Storage Above Spillway $230.4(185.4-179.6) = 1,336$ ac ft
Storage Below Spillway $\frac{1}{3}(230.4)(179.6-156.1) = 1,805$ " "
Total Storage 3,141 " "

Channel Hydraulics: Failure flow would move toward over Res. No. 1 after passing over Rte 9, which could act as a broad crested weir, creating a flood pool in part of the housing development to the north of Rte 9. The effective "weir" of Rte 9 is taken as follows:



Adjust V Weir formula for broad crest flow by 2.55 ÷ 3.33

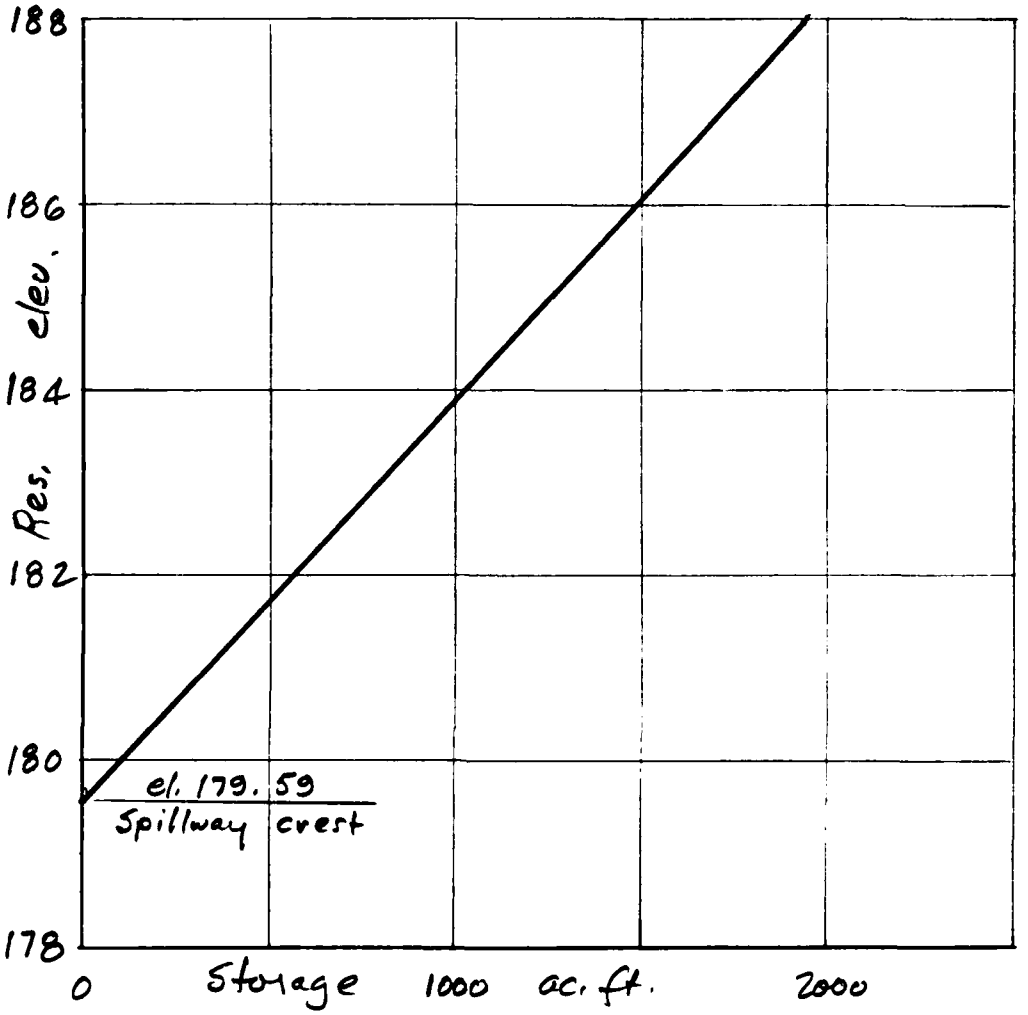
$$Q = \frac{2.55}{3.33}\left(\frac{4}{15}\right)\frac{1000}{9.3}(2g)^{1/2}H^{2.5} = 176.2\,H^{2.5}$$

Ref. 1 "Hydraulics" Hughes & Safford, pg 176

H	2	4	6	8	7	7.5
Q	1000	5640	15540	31900	22840	27140
Elev.	171.3	173.3	175.3	177.3	176.3	176.8

Dam failure could cause a flood pool at ±el 176.5 in residential area. This is ±5 feet above the ground level at houses near Rte 9. Impact of failure flow could act at higher levels.

(IX) Storage vs Res. Elev.



Note: Res. area is assumed to be constant at 230.4 acres for the reservoir levels shown.

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APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

FOSS RESERVOIR DAM

NOT AVAILABLE AT THIS TIME

END

FILMED

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DTIC